

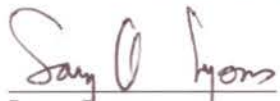
**REPORT 1 OF 2
RARITAN BAY SLAG SITE
OLD BRIDGE AND SAYREVILLE, MIDDLESEX COUNTY, NEW JERSEY**

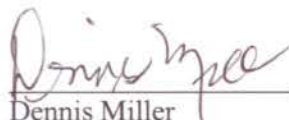
CHEMICAL ASSESSMENT REPORT

**CHARACTERIZATION OF SLAG\WASTE MATERIAL
FATE AND TRANSPORT OF CONTAMINANTS
BIOMONITORING OF CONTAMINANTS**

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LIST OF ACRONYMS AND ABBREVIATIONS

Ag	Silver
As	Arsenic
AsCuS	Arsenic copper sulfide
CFR	Code of Federal Regulations
cm	centimeter
Cr	Chromium
Cu	Copper
CuO ₂	Cuprite
g	gram
EPA	Environmental Protection Agency
ERT	Emergency Response Team
Fe	Iron
ICP-AES	Inductively Coupled Plasma – Atomic Emission Spectrometry
M	molar
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
Mn	Manganese
Ni	Nickel
NJ	New Jersey
NJDEP	New Jersey Department of Environmental Protection
oz	ounce
Pb	Lead
PbCO ₃	Lead Carbonate
PbO	Lead Oxide
Pb(OH)Cl	Lead Hydroxide Chloride
Pb ₂ OSO ₄	Lanarkite
PbS	Lead Sulfide
PbSO ₄	Lead Sulfate
PbZrO ₃	Lead Zirconium Oxide
RCRA	Resource Conservation and Recovery Act
REAC	Response, Engineering and Analytical Contract
Sb	Antimony
SiO ₂	Silicate
SOP	Standard Operating Procedure
Sn	Tin
TAL	Target Analyte List
TCLP	Toxicity Characteristic Leaching Procedure
U	not detected
µg/L	microgram per liter
µm	micron
U.S.	United States
WA	work assignment
XRD	X-ray Diffraction
Zn	Zinc
%	percent
<	less than

EXECUTIVE SUMMARY

The Raritan Bay Slag site, located in Old Bridge and Sayreville, New Jersey (NJ), extends approximately 1.5 miles from Margaret's Creek Wetlands Area along the seawall adjacent to the Old Bridge Waterfront Park to the waterfront area just west of the Cheesequake Creek Inlet western jetty. In the late 1960s and early 1970s, lead-bearing slag and other demolition material were used as fill and stabilizing material for the construction of the seawall. In addition, slag and associated materials were used to build-up the western jetty at the Cheesequake Creek Inlet.

The objectives of this work assignment (WA) were to characterize the metallurgical waste material at the site; evaluate the potential for release and transport of contaminants associated with the waste material; collect data in support of human and ecological risk assessment; and conduct an initial ecological risk assessment. Final results are presented in two separate documents. This document presents the data collected and an assessment of the data relative to the chemical nature, fate and transport of the contaminants. A second document utilizes the same data in an initial ecological risk assessment (EPA/ERT/REAC 2009).

The results of this evaluation are as follows:

- Slag from the seawall, Cheesequake Creek Inlet western jetty and along the beachfront west of the jetty was highly heterogeneous with a wide range of concentrations. Particularly high concentrations were found for arsenic (As), copper (Cu), lead (Pb), antimony (Sb), tin (Sn) and zinc (Zn). Lead concentrations exceeded 10,000 mg/kg for 15 of the 17 samples analyzed and exceeded 100,000 mg/kg for 5 of the 17 samples analyzed
- Metal speciation analysis of the slag reinforced the conclusion of heterogeneity of the material present, and confirmed that it was metallurgical waste material. The analyses identified various Pb, Cu, As and Sn compounds as dominant species. Five different Pb species were identified as dominant species in the slag. Of particular importance was the finding that interior and exterior layers of the slag contained different Pb species, with the interior layers containing Pb species with greater affinity to mobilize from the potential weathering and erosion of the slag. This finding is consistent with a conclusion that the slag is weathering.
- The leachability and/or mobility of the metals from the slag were evaluated under acidic conditions following Toxicity Characteristic Leaching Procedure (TCLP) methods. All 17 slag samples exceeded the Resource Conservation and Recovery Act (RCRA) regulatory limit for Pb of 5.0 mg/L based on TCLP, designating the slag as hazardous waste. Leachable metal determinations were also presented as concentration leached based on dry weight. Lead concentrations leached from the slag exceeded 1,000 mg/kg for 15 of the 17 slag samples, with 10 samples having leachable Pb concentrations exceeding 10,000 mg/kg.
- The leachability and/or mobility of the metals from the slag were also evaluated using neutral salt solutions. Particularly high levels of Pb were determined to be leachable and/or mobilized from neutral salt solutions with higher levels of leachable Pb in the interior (non-weathered) samples compared with the exterior layer of the slag boulders. This finding is consistent with a conclusion that contaminants within the slag are leachable and therefore able to be released into the environment under normal conditions at the site.
- Soil (*i.e.*, beach sediments) and pore water collected along the intertidal zone adjacent to the seawall had high metal concentrations consistent with the release of metals from the slag. Soils along the entire length of the intertidal zone adjacent to the seawall are characterized as having a

high spatial variability, with a wide range of concentrations, particularly for Pb, Sb, As and Cu. Pore water was analyzed for dissolved metals and total metals. High concentrations of total Pb, manganese (Mn), As and Sb were measured in the unfiltered samples. In addition, high concentrations of dissolved Mn, Pb As, and Sb were measured for several of the filtered samples. The wide variation of contaminant concentrations in the soils and pore water is consistent with the influence of Site characteristics. The finding of elevated pore water metal concentrations is of particular importance as this supports a conclusion that Site contaminants are being released into the environment.

- Biomonitoring techniques were utilized to assessing contaminant release and transport. These techniques are particularly useful in locations with periodic or sporadic contaminant releases. Utilizing the principles of biomonitoring, biota sampling focused on the predominant organisms that were residing or utilizing the intertidal and subtidal zones at this site to determine which organisms would accumulate contaminants released from the seawall. The organisms collected from the intertidal zone included two mollusks (ribbed mussels [*Geukensia demissa*] and long neck or steamer clams [*Mya arenaria*]), macroalgae (*Ulva*), and foraging fish (killifish). In addition, hard shell clams (*Mercenaria mercenaria*) were collected in the subtidal zone. *Ulva* had the highest metal accumulations for Pb, Mn, As, chromium (Cr) and nickel (Ni). Of the three mollusks, juvenile *Mya* clams accumulated the highest concentrations of Pb and Cu. All three mollusks accumulated comparable concentrations of As and silver (Ag). The biomonitoring data are consistent with a conclusion that Site contaminants are being released into the environment and are being biologically accumulated. The biota data also support a conclusion that the contaminants are being transported away from the source material; this conclusion is supported by the accumulation of contaminants in biota not residing immediately adjacent to the slag material.

1.0 INTRODUCTION

The Raritan Bay Slag site (the Site), located in Old Bridge Township and the Borough of Sayreville, New Jersey (NJ), is approximately 1.5 miles in length and consists of the waterfront area between Margaret's Creek and the area just beyond the western jetty at the Cheesequake Creek Inlet. The Site consists of a sea wall that extends for approximately 2,500 feet along the Old Bridge Waterfront Park adjacent to Bayview Drive in Laurence Harbor, public beach areas, three jetties, the Cheesequake Creek Inlet western jetty that extends for about 800 feet from the mouth of the Cheesequake Creek into Raritan Bay and the waterfront area west of the jetty (Figure 1).

In September 1972, the New Jersey Department of Environmental Protection (NJDEP) was advised by a local environmental commission member that lead-bearing waste material was being deposited along the Laurence Harbor beachfront. The material was reported to be non-recoverable, low-yield metallic waste from a blast furnace and blast furnace rubble. The slag was deposited at the beachfront in the late 1960s and early 1970s, mostly in the form of blast furnace pot bottoms, in an area that had sustained significant beach erosion and damage due to a series of storms in the 1960s. Demolition debris in the form of concrete and a variety of bricks, including fire bricks, was also placed along the beachfront. A portion of the seawall also contains large riprap believed to have been placed over the slag when the grassed and paved portion of the park was developed.

The western jetty at Cheesequake Creek Inlet has been in existence since the United States (U.S.) Army Corps of Engineers constructed it in the late nineteenth century. The slag was reportedly placed on the jetty during the same general time period as the construction of the seawall. The entire jetty is covered with slag that is similar in appearance to that which is present on the seawall. The waste material and slag was used to supplement the jetty and was used as a fill and stabilizing material for the seawall. Metal contaminants associated with the slag and associated waste material include antimony (Sb), arsenic (As), copper (Cu), lead (Pb), manganese (Mn), nickel (Ni), zinc (Zn), and tin (Sn).

Under this work assignment (WA), the U.S. Environmental Protection Agency (EPA)/Emergency Response Team (ERT) requested Response Engineering and Analytical Contract (REAC) personnel to perform both chemical and biological assessments that are presented as separate reports. The biological assessment evaluates the risk/impact of the metals being released from the slag on the biological communities associated with the intertidal zone adjacent to the sea wall (EPA/ERT/REAC 2009). The objectives of this chemical assessment report include:

- Characterization of the metal contaminants associated with the slag and waste material used for the construction of the sea wall and Cheesequake Creek Inlet Western Jetty;
- Evaluation of the leachability and mobility of metals from the slag and associated waste material;
- Assessment of contaminant release through biomonitoring techniques;
- Evaluation of the fate and transport of the metals in environmental media including soils (*i.e.*, beach sediments), pore water and biota of the intertidal zone adjacent to the sea wall;
- Collection of data relevant to human health and ecological risk assessments.

2.0 SITE SETTING AND DESCRIPTION

The Site is bordered to the south, east, and west by residential properties and State Highway 35, and to the north by Raritan Bay. The Site extends for approximately 1.5 miles and includes the Old Bridge Waterfront Park, public beaches, three jetties, the Cheesquake Creek Inlet western jetty and the waterfront area west of the jetty (Figures 1, 2 and 3). The Old Bridge Waterfront Park, consisting of walking paths, gazebo and public parking area, is protected by a seawall, which is constructed with layers of slag and fill. Slag and fragments of slag are scattered along the entire length of the beach area between the seawall and cordgrass (*Spartina alterniflora*) beds (Figure 4). Figure 5 depicts the slag at the top of the seawall during high tide. Figures 6 and 7 depict the Cheesquake Creek Inlet western jetty at high tide when the water has risen to close to the top of the jetty and Figures 8 and 9 depict an assortment of slag used for constructing the jetty. Figure 10 shows the waterfront area just west of the jetty with slag and fragments of slag scattered along the waterfront.

Intertidal Zone Along Seawall

The intertidal zone adjacent to the seawall (Figures 1 and 2) consists of an open stretch of beach with slag and slag debris that extends for 20 to 30 feet before reaching the *Spartina* beds. Figure 4 depicts the area along the seawall within the intertidal zone at low tide with the *Spartina* beds situated adjacent to the seawall. The *Spartina* beds (Figure 11) extend for 10 to 15 feet within the mid to high tide range of the intertidal zone along the entire length of the seawall. The intertidal zone immediately beyond the *Spartina* beds primarily consists of open sand beach, cobble stones to medium sized rocks and randomly scattered slag. The green macroalgae (*Ulva* sp) was attached to the bottom substrate or to the cobble stones or rocks within this area that extended from the mid tidal level to beyond the low tidal level. It was noted that the *Ulva* did not colonize or attach to the slag that was scattered in this area. The *Ulva* was prominent but was not growing profusely within this intertidal zone.

Invertebrates that were prevalent in the intertidal zone either within or in proximity of the *Spartina* beds were limited to two species of mollusks: ribbed mussel (*Geukensia demissa*) (Figure 12) and long neck or steamer clam (*Mya arenaria*) (Figure 13). A dense colony of ribbed mussels was situated within the *Spartina* beds buried just below the surface of the sediments with a portion of the bivalve shell slightly extending above the surface of the sediments, allowing for the siphon to be extended into the water column for filtering. Most of the *Mya* clams were completely buried in the sediments from just below the surface to depths of six to eight inches. The hard shell clam (*Mercenaria mercenaria*) was found inhabiting the subtidal zone just beyond the intertidal zone. The hard shell clams were buried in the sediment at just below the surface. The biological assessment report for this WA provides an evaluation of the exposure of the organisms to metals associated with the slag boulders in this intertidal zone (EPA/ERT/REAC 2009).

3.0 SAMPLING DESIGN AND METHODS

The sampling design focused upon two primary objectives. One objective was to collect a representative assortment of waste rock/slag samples to characterize the metals associated with and leaching from the slag. Slag samples were collected along the sea wall, along the Cheesquake Creek Inlet western jetty and along the waterfront area west of the jetty. The slag samples were analyzed for total metals and for identification of the dominant metal species. In addition, the mobility and/or leaching potential of the metals associated with the slag were assessed based on Toxicity Characteristic Leaching Procedure (TCLP) methods and use of neutral salt solution to

simulate seawater. This evaluation also included a characterization of exterior and interior slag samples.

The second objective of the sampling design was to document the release of contaminants from source areas and assess the fate and transport of the metals leaching from the slag and associated waste material. This second objective was met by a biomonitoring approach, utilizing both chemical analyses of abiotic media (soil and pore water) and evaluation of the contaminant uptake by the biota inhabiting or utilizing the intertidal and subtidal zones along the seawall. The criteria for the selection of target biomonitoring species were taken from Boening 1999; Butler 1971; Phillips 1977; and Phillips 1978, and are as follows:

- The organisms can integrate exposure over time;
- The organisms feeding strategy and/or other behavior characteristics establish an exposure pathway consistent with environmental chemistry of the contaminant of interest;
- The organism can concentrate contaminants and, therefore allow the evaluation of contaminants that are present in the environment at or below the analytical detection limit;
- The organism accumulates the pollutant without being adversely affected, if possible;
- The organism is an important foraging food source for higher level biota;
- The organism is sedentary (sessile) in order to be representative of the area of collection;
- The organism is abundant in the study area;
- The organism is sufficiently long lived to allow the sampling of more than one year class, if possible;
- The organism is of reasonable size to provide adequate tissue for analyses and accurate weight measurement; and
- The organism is easy to collect/sample and hardy enough to survive in the laboratory, allowing depuration (clearing) before chemical analyses.

The organisms chosen for the biomonitoring sampling were selected in an attempt to meet as many of the above criteria as possible given the species that are actually present at the Raritan Bay Slag Site. One of the primary considerations was the ability to bioaccumulate metals being released from the slag. In addition, there was consideration as to whether animals and plants at the site could potentially be consumed by human or ecological receptors (to increase the utility of the data generated). Based on the field reconnaissance of the sampling area and the organism selection criteria above, several target species were identified for sampling, including mollusks (ribbed mussels, long neck clam and hard shell clam), polychaetes, macroalgae (*Ulva*) and foraging fish (killifish).

Mollusks or bivalves are known to be effective biomonitors of metal contaminants meeting many of the criteria for an ideal biomonitoring organism; however, no one particular species is universally suitable. When possible and practical it is advisable to initiate a biomonitoring assessment using several species representing different exposure pathways (Boening 1999). The three prominent bivalves (ribbed mussel, long neck clam and hard shell clam) at this Site represent different feeding and/or habitat characteristics.

Ulva species have demonstrated their capability as biomonitors of metal contamination including Cu, Pb, Mn, Ni and Zn (Besada *et al.* 2009, Villares *et al.* 2005, 2001, 2002, Ho 1990). Both the laminar structure of this macroalgae, providing a high surface area to volume ratio, and its

capacity to grow in contaminated areas increases its potential as a useful biomonitor.

Killifish (*Fundulus* sp.) were the predominant foraging fish utilizing the intertidal zone at the Site. In addition, killifish are known to have a limited seasonal home range (Lotrich 1975). The killifish continuously move in and out of this intertidal zone with the tide and could potentially be exposed to the metals associated with the slag via surface water and foraging.

Polychaetes, residing within the interstitial sediments of this intertidal zone, would be in direct contact with the sediments and pore water that could be contaminated with metals associated with the slag. However, the population density of the polychaete community within this intertidal zone was too small for effective sampling during the site investigation. Local residents were observed collecting worms to be used for bait along the beach area just east of the sea wall. Numerous worms were easily collected by the local residents with the use of a trowel, with the largest worms ranging in size up to several inches in length. No evidence of these same type of worms were found along the seawall.

Soil and pore water sampling was co-located with the biota sampling, particularly for the ribbed mussels and *Mya* clams, to integrate exposure from the environmental media at the same locations.

The site investigation activities occurred over four sampling days on September 10, 11, 19 and 22, 2008. Sampling and analytical methods are provided in the following sections.

3.1 Slag Sampling and Analytical Methods

Sampling of the slag was performed by identifying and selecting individual pieces of slag along the seawall, the Cheesequake Creek Inlet western jetty and at the waterfront area west of the jetty. A total of 17 pieces of slag was collected by chiseling off fragments from the slag using a cole chisel and hammer.

Appendix C provides the photographs of the slag and samples. Figures C-1 to C-8 show the five slag samples originating from the seawall, identified as samples SW-1 through SW-5. Figures C-9 to C-20 show the 10 slag originating from the jetty from which samples were chiseled. These samples are designated as Jetty 1, 2A, 2B, 3A, 3B, 4, 5, 6, 7A and 7B. Figures C-21 and C-22 show the slag along the waterfront just west of the jetty from which samples were collected, designated as West Jetty 1 and 2.

Six slag samples from the jetty were collected by chiseling off just the exterior crust from the slag (Jetty 2A, 3A and 7A) and then chiseling off an interior sample below the crust (Jetty 2B, 3B and 7B). All of the remaining slag samples are whole samples that consist of exterior and interior layers of the slag.

All slag samples were pulverized and homogenized to a powder in the laboratory using a puck mill. The pulverized slag samples were analyzed for total metal concentrations of As, Cu, Pb, Sb, Sn and Zn by Inductively Coupled Plasma – Atomic Emission Spectrometry (ICP-AES) following acid digestion. X-ray diffraction (XRD) was used for metal speciation determinations. In addition, the potential leachability or mobility of the metals from the 17 slag samples was evaluated based on exposure to acidic conditions as defined by the Toxicity Characteristic Leaching Procedure (TCLP) and by exposure to a neutral (weak) salt solution (0.01 molar [M] calcium chloride solution). Appendix A provides the analytical report and the standard operating procedures (SOPs).

Ten soil samples (*i.e.*, beach sediments) collected by Weston Solutions, Inc. adjacent to slag were analyzed for total metals by ICP-AES and for metal speciation by XRD. Five samples were collected along the intertidal zone adjacent to the seawall and five samples were collected along or near the Cheesequake Creek Inlet western jetty (Weston Solutions 2009).

3.2 Soil Sampling and Analytical Methods

A total of 11 co-located soil (*i.e.*, beach sediment) samples were collected at the ribbed mussel and *Mya* clam collection points (Figure 2). The soil samples were collected after the ribbed mussels and *Mya* clams were collected to avoid disturbing the biota. Soil samples were collected with a trowel and placed into 8-ounce (oz) glass jars. Samples were shipped to the subcontract laboratory and were analyzed for target analyte list (TAL) metals and Sn.

3.3 Pore Water Sampling and Analytical Methods

Pore water samples were collected by inserting a glass pipette into the soil at a depth of 1.5 to 2 inches below the surface. The end of the pipette that was inserted into the soil was covered with nylon screen to prevent the entrainment of soil. The pore water was siphoned through the pipette using a portable peristaltic pump. Individual decontaminated pipettes and tubing were used for collecting each sample. Five pore water samples were collected. Each of the samples was collected within proximity of the *Mya* clam collection points (Figure 2). The pore water was collected when the tide water had receded to avoid collection of surface water. One half of each sample volume was filtered by passing the water through a 0.45 micron (μm) filter and preserved to a pH of less than ($<$) 2.0 standard units with nitric acid. The other half of each sample was not filtered and preserved to pH $<$ 2.0. Pore water samples were shipped to the subcontract laboratory and were analyzed for TAL metals and Sn as total metals and filtered dissolved metals.

3.4 Killifish (*Fundulus* sp.) Sampling and Analytical Methods

Five composite samples of killifish each consisting of eight individual fish were collected along the seawall during mid-tide using a seine net. Figure 2 presents the sampling area where the seining occurred. The killifish were placed into 2.5-gallon pails containing aerated seawater and transported back to the ERT/REAC Biological Laboratory for a depuration period of 24 hours. Following the depuration period, each composite sample was weighed, placed into glass jars and frozen. Samples were shipped to the subcontract laboratory, homogenized and analyzed for target analyte list (TAL) metals, Sn and percent (%) solids.

3.5 Ribbed Mussel (*Geukensia demissa*) Sampling and Analytical Methods

Ribbed mussels were collected at six areas along the seawall at mid-tide. Figure 2 presents the six sampling locations designated as RM-1 to RM-6. The ribbed mussels were found to be prevalent amongst the *Spartina* (marsh grass) beds that are approximately 40 to 60 feet from the seawall. The ribbed mussels, most of which were seen projecting from the sediment, were collected by hand and ranged in size from 3.8 to 8.0 centimeters (cm). Eight to twelve ribbed mussels were collected at each sampling location to produce six composite samples, placed into large glass jars containing Rartian

Bay water, aerated and brought back to the ERT/REAC Biological Laboratory for a depuration period of 24 hours. Following the depuration period, each composite sample was weighed, placed into a 16 ounce (oz). glass jar and frozen. The tissue was removed from each bivalve shell while frozen and the composite sample of the tissue was weighed. Tissue samples were shipped frozen to the subcontract laboratory, homogenized and analyzed for TAL metals, Sn and % solids.

3.6 Long Neck Clam (*Mya arenaria*) Sampling and Analytical Methods

Mya clams were collected at five areas along the seawall at mid-tide within or near the *Spartina* beds. Figure 2 presents the five sampling locations (*Mya* 1 to *Mya* 5). The *Mya* clams were either observed partially buried in the sediment and collected by hand or were collected using a clam rake. The clams ranged in size from 1 to 4 cm with the number of individual clams in each composite sample ranging from 5 clams for *Mya*-3 to 106 clams for *Mya*-2. The clams were transported back to the ERT/REAC Biological Laboratory alive, placed into large glass flasks with Raritan Bay water and aerated for a depuration period of 24 hours. Following the depuration period, each composite sample was weighed, placed into a 16 oz. glass jar and frozen. The tissue from each clam was removed while frozen and the composite sample of tissue was weighed. Samples were shipped frozen to the subcontract laboratory, homogenized and analyzed for TAL metals, Sn and % solids.

3.7 Hard Shell Clam (*Mercenaria mercenaria*) Sampling and Analytical Methods

Mercenaria were collected using a clam rake at a water depth of 3.5 to 4 feet at mid-level tide just offshore of the sea wall. Figure 2 presents the approximate area from which the clams were collected. After numerous hauls with the clam rake, a total of 10 clams were collected at three different size ranges (2.0 inches, 2.5 inches and 3.5 inches). The clams were subdivided into three composite samples based on the three size ranges. The clams were transported back to the ERT/REAC Biological Laboratory alive, placed into large glass flasks with Raritan Bay water and aerated for a depuration period of 24 hours. Following the depuration period, each composite sample was weighed, placed into a glass jar and frozen. The tissue from each clam was removed while frozen and the composite sample of the tissue was weighed. Tissue samples were shipped frozen to the subcontract laboratory, homogenized and analyzed for TAL metals, Sn and % solids.

3.8 Polychaete Sampling

Sampling for polychaete worms was performed by collecting sediment at the low to mid-tide level with a clam rake, transferring the sediment onto a sieve and washing the sediment through the sieve to separate the polychaetes from the sediment. Collections were attempted at depths from just below the surface to a depth of approximately 10 inches. However, only a few small polychaetes (<1 to 2 inches in size) were collected after sieving numerous sediment samples. This amounted to no more than 2.1 grams (g) wet weight, providing an insufficient volume of biomass to meet the data quality objectives

3.9 Sea Lettuce (*Ulva*) Sampling and Analytical Methods

Ulva was prevalent attached to bottom substrate (mostly attached to large stones and rocks) just beyond the *Spartina* beds at the mid-tide level. It was noted that attached *Ulva*

was missing or sparse on the waste rock that was lying in these areas. Figure 2 presents the five sampling locations where the *Ulva* was collected and composited. Each of the composite samples was collected by hand, placed into a ziplock bag and brought back to the ERT/REAC Biological Laboratory. The *Ulva* was transferred to a sieve to be washed with distilled water, then blotted dry, transferred to sampling jars and frozen. Samples were shipped to the subcontract laboratory, homogenized and analyzed for TAL metals, Sn and % solids.

4.0 ANALYTICAL RESULTS

Appendix A provides the analytical report for the characterization of the slag. Section 4.1 provides an overview of the results. Appendix B provides the analytical report for the soil, pore water and biota. Sections 4.1 to 4.6 summarize the results.

4.1 Characterization of Slag and Soil Samples

A total of 17 slag samples were collected from the seawall, Cheesequake Creek Inlet western jetty and the waterfront area west of the jetty. Appendix C provides the photographs of the slag samples and Section 3.1 describes the samples collected.

Each of these 17 slag samples was analyzed for total elemental concentration for the primary metals of interest (As, Cu, Pb, Sb, Sn and Zn) along with the identification of the dominant mineral or chemical species using XRD procedures. In addition, two leachability tests assessing the mobility of the metals from the slag were performed. One test, TCLP, evaluated leachability under acidic conditions. The other test evaluated the leachability of metals from the slag when exposed to a neutral salt solution. Appendix A provides the analytical report. A summary of the results are provided below.

Ten soil samples collected by Weston Solutions, Inc. were also analyzed for total metal concentrations along with the identification of the dominant mineral or chemical species. Five of these samples were collected along the seawall within the intertidal zone and five samples were collected along or near the Cheesequake Creek Inlet western jetty (Weston Solutions 2009).

Total Metal Concentrations

The slag samples are characterized as highly heterogeneous with a wide variation in elevated metal concentrations among the samples (Table 1a). Arsenic ranged from 8 mg/kg for Jetty 1 to 15,200 mg/kg for West Jetty-1. One particularly high concentration (445,000 mg/kg or 44.5%) of Cu was found in sample SW-2. Copper concentrations ranged from 101 mg/kg (Jetty 1) to 18,200 mg/kg (SW-3) for the remaining slag samples. With the exception of two samples (SW-2 and Jetty-1), the slag samples had Pb concentrations greater than 10,000 mg/kg, ranging from 12,900 mg/kg for West Jetty-2 to 131,000 mg/kg for Jetty-5. Antimony concentrations ranged from 31 mg/kg for Jetty-1 to 71,300 mg/kg for SW-1 and Sn ranged from 25 mg/kg for SW-2 to 11,400 mg/kg for Jetty-7A. Zinc concentrations ranged from 49 mg/kg for SW-2 to 13,400 mg/kg for SW-3 (Table 1a).

Table 2a presents the results for the ten soil samples collected adjacent to slag. Three of the five soil samples along the seawall had Pb concentrations above 1,000 mg/kg, ranging from 1,130 mg/kg to 2,580 mg/kg. The highest Pb concentrations (maximum

concentration of 173,000 mg/kg) were from samples collected along or near the Cheesequake Creek Inlet western jetty. Additionally, the five soil samples collected along or near the Cheesequake Creek Inlet western jetty had elevated concentrations of As, Cu, Pb, Sb, Sn and Zn that exceeded 1,000 mg/kg (Table 2a).

Compound Speciation of Metals (XRD Analyses)

The XRD analyses performed on the slag and soil samples identified the crystal form of the dominant compound or species based on an initial phase identification.

Table 1b presents the dominant species identified for the slag samples. In many of the slag samples, there is a strong correlation between the total metal concentrations (Table 1a) and the dominant compounds identified by XRD (Table 1b). Iron (Fe) species and silicate (SiO_2) species were identified as dominant species for most of the samples and also various Pb, Cu, As and Sn species were also identified as dominant species. The dominant Pb species identified for a number of the slag samples included elemental Pb, lead carbonate (PbCO_3), lead zirconium oxide (PbZrO_3), lead sulfate (PbSO_4), and lead oxide (PbO). Different Pb species were identified in exterior versus interior layers of three slag boulders (*i.e.*, samples Jetty 2A, 2B, 3A, 3B, 7A and 7B). The interior samples contained lead carbonate (PbCO_3) as the dominant species, whereas the dominant species identified for the exterior samples included elemental Pb and PbZrO_3 .

In Sample SW-2 (Cu concentration of 445,000 mg/kg) cuprite (Cu_2O) was the dominant species. Sample West Jetty 1 (As concentration of 15,200 mg/kg) contained arsenic copper sulfide (AsCuS) as a dominant species (Tables 1a and 1b)

Table 2b presents the dominant species identified for the soil samples. The four samples collected near the Cheesequake Creek Inlet western jetty with the highest Pb concentrations (*i.e.*, samples 48, 50, 51 and 52 collected by Weston Solutions, Inc.) contained several Pb species including PbCO_3 , lead sulfide (PbS), lead hydroxide chloride (Pb(OH)Cl), lanarkite (Pb_2OSO_4), laurionite (PbOHCl) and lead sulfate (PbSO_4).

Toxicity Characteristic Leaching Procedure (TCLP)

The TCLP procedure was employed to determine the mobility of the metal contaminants from the slag under acidic conditions. The primary objective of the TCLP analysis is to simulate landfill conditions to assess if, over time, water or other liquids will react with the waste material or slag to mobilize contaminants and thus pose public health or environmental risk. The TCLP results are reported as the concentration in the aqueous phase as milligrams per liter (mg/L) (Table 3a) and as total elemental solids leaching from the slag as mg/kg dry weight (Table 3b).

Regulatory limits established under the Resource Conservation and Recovery Act (RCRA) (under Code of Federal Regulations [CFR] 40 CFR 261.24) are defined for both As and Pb as 5.0 mg/L. All of the 17 slag samples far exceed the 5.0 mg/L level for Pb with leachable Pb levels ranging from 17 mg/L to 3,140 mg/L (Table 3a). RCRA does not establish regulatory limits for the other metals analyzed. Arsenic levels in the leachate did not exceed the regulatory limit.

The TCLP analyses demonstrated that each of the 17 waste rock/slag samples leached Pb at concentrations ranging from 349 mg/kg to 62,700 mg/kg. Only two of the waste rock

samples (SW-2 and Jetty-1) had concentrations of leachable Pb below 1,000 mg/kg; five waste rock samples exceeded 1,000 mg/kg and the remaining 10 samples exceeded 10,000 mg/kg (Table 3b). Slag sample SW-2 which contained the highest Cu concentration (445,000 mg/kg) had a leachable Cu concentration of 16,900 mg/kg (Table 3a). The slag samples did not leach appreciable quantities of the other metals with the exception of sample SW-5 which leached 1,005 mg/kg of Zn.

Leachability of Metals from Neutral Salt Exposure

Neutral salt extraction procedure was used to simulate the potential leachability and/or mobility of the metal contaminants from the slag from exposure to seawater.

Lead was determined to be leachable under these conditions (Table 3c). It was also demonstrated that the interior slag samples (samples Jetty 2B, 3B and 7B) had considerably higher levels of leachable Pb when compared with the leachable Pb levels from the exterior slag samples (samples Jetty 2A, 3A, and 7A). The exterior samples, essentially the outer crust of the slag, yielded leachable Pb levels of 8.3 mg/kg, 1.3 mg/kg and 10.1 mg/kg for samples Jetty 2A, 3A, and 7A, respectively. In comparison, the interior samples, that have not been previously exposed to Raritan Bay water, leached Pb at significantly higher levels (610 mg/kg, 870 mg/kg and 70.9 mg/kg for samples Jetty 2B, 3B and 7B, respectively) (Table 3c). As discussed above, the XRD characterization demonstrated differences in Pb species between the interior and exterior samples. The dominant Pb species for two of the three interior samples was identified as PbCO_3 , which would have a greater affinity for leaching than the dominant Pb species for the exterior samples (elemental Pb and PbZrO_3).

Two other slag samples (samples Jetty 5 and Jetty 6) that are composite samples containing both interior and exterior layers also had high levels of leachable Pb with concentrations of 505 mg/kg and 72.2 mg/kg, respectively. Arsenic, Cu, Sb and Sn did not leach under the neutral salt water extraction. Zinc was leachable for a few of the slag samples with the highest leachable Zn level (126 mg/kg) for the Jetty-5 slag sample.

4.2 Pore Water Results

Five pore water samples were collected in the intertidal zone within proximity of the collection sites for the *Mya* (long neck shell) clams. Table 4 summarizes the results (as ug/L) for both the total metals in unfiltered and filtered samples.

Lead levels in the filtered and unfiltered pore water samples differed. Two particularly high Pb values (1,500 ug/L and 2,400 ug/L) were determined for the unfiltered pore water samples. Correspondingly, dissolved Pb values ranged from < 2.0 ug/L to a maximum value of 170 ug/L. The maximum Sb concentrations in the two unfiltered pore water samples were 56 ug/L and 270 ug/L and the maximum dissolved Sb concentrations were 19 ug/L and 130 ug/L, respectively. Dissolved As levels ranged from 11 ug/L to 86 ug/L and total As levels ranged from 19 ug/L to 230 ug/L.

Total and dissolved Mn levels were quite similar, ranging from 530 ug/L to 2,300 ug/L, indicating that Mn in the pore water was essentially available as dissolved metal. Copper and Zn concentrations were mostly below detection limits for both the total and dissolved metals.

A comparison of the metal concentrations in the surface water collected along the intertidal zone adjacent to the seawall by Weston Solutions, Inc (Weston Solutions 2009) during the same time period as this study reveals that certain metals were more concentrated in the pore water than surface water. For example, Mn levels in the surface water ranged between 100 ug/L to 200 ug/L and As ranged between < 10 ug/L to 11 ug/L as dissolved metal. Dissolved Pb levels in the pore water were comparable to the surface water levels along the seawall, ranging from 11.9 ug/L to 152 ug/L (Figure 5 in Weston Solutions 2009).

4.3 Soil Results

Eleven soil (*i.e.*, beach sediment) samples were collected within proximity of the collection sites for the ribbed mussels and the *Mya* clams (Table 4). In addition, 18 soil samples were collected along the seawall during the same time period as this study (September 2008) by Weston Solutions, Inc. (2009) (Table 5). The sampling locations of these 18 samples are shown in Figure 3.

The metal concentrations (Tables 4 and 5) in the soil samples along the seawall were highly heterogenous, analogous to what would be expected within a contaminated landfill site. Lead levels particularly stand out with concentrations ranging from 12 mg/kg to 5,860 mg/kg (Tables 4 and 5). Likewise, Sb ranges from 0.2 mg/kg to 232 mg/kg, As ranges from 2 mg/kg to 29 mg/kg and Cu ranges from 4.4 mg/kg to 248 mg/kg.

4.4 Mollusk Bioaccumulation Results

Five composite samples of the long neck clams (*Mya*), six composite samples of the ribbed mussels and three composite samples of the hard shell clams were analyzed for metals. Analyses were only performed on the soft tissue. The bivalve shells of the mollusks were discarded. Only juvenile *Mya* clams, less than one year old, were collected from the intertidal zone along the seawall. No adult *Mya* clams were found. Both the ribbed mussel and the hard shell clam composite samples were composed entirely of adult clams that were greater than two to four years old.

Tissue concentrations of Pb and Cu were highest in the juvenile *Mya* clams compared with either the adult ribbed mussels or the adult hard shell clams (Table 4). Lead levels for the *Mya* clams ranged from 3.4 mg/kg to 17 mg/kg (mean of 13.1 mg/kg) whereas ribbed mussels had Pb levels ranging from 3.0 mg/kg to 8.6 mg/kg (mean of 5.0 mg/kg) and the hard shell clam had Pb ranging from 1.7 mg/kg to 3.1 mg/kg (mean of 2.6 mg/kg). Copper levels for the *Mya* clams ranged from 8.5 mg/kg to 31 mg/kg (mean of 21.3 mg/kg) whereas Cu levels in ribbed mussels ranged from 10.4 mg/kg to 16 mg/kg (mean of 13.5 mg/kg) and the Cu levels in the hard shell clams ranged from 11 mg/kg to 14.3 mg/g (mean of 13.1 mg/kg).

Manganese levels were significantly higher in the *Mya* clams (4.3 mg/kg to 130 mg/kg) compared with the ribbed mussels (4.4 mg/kg to 7.1 mg/kg), but were lower than Mn levels in the hard shell clams (52 mg/kg to 200 mg/kg). Arsenic and Ag levels were comparable among all three mollusks with levels ranging from 1.4 mg/kg to 9.8 mg/kg for As and 0.15 mg/kg to 2.1 mg/kg for Ag. Zinc levels were higher in the *Mya* clams and hard shell clams than the ribbed mussels, but within the same range for the hard shell clams (Table 4).

4.5 *Ulva* Bioaccumulation Results

Five composite samples of *Ulva* collected within the intertidal zone were analyzed for metal concentrations. The *Ulva* bioconcentrated As, Cr, Pb, Mn and Ni at higher levels than the other biota (Table 4). Lead, Mn and Ni concentrations in the *Ulva* are of particular note with concentrations of 24 mg/kg to 80 mg/kg for Pb, 120 mg/kg to 280 mg/kg for Mn and 2.6 mg/kg to 4.7 mg/kg for Ni. Arsenic concentrations in the *Ulva* ranged from 4.7 mg/kg to 15 mg/kg and Cr ranged from 2.6 mg/kg to 5.0 mg/kg.

4.6 Foraging Fish (*Fundulus* sp.) Bioaccumulation Results

Five composite samples of killifish (*Fundulus* sp.) were analyzed for metals. Killifish exposure to the metal contaminants within the intertidal zone would primarily be the result of surface water exposure and foraging as the fish move in and out of the area with the tide. Data was collected for only one sampling area. Arsenic, Cu, Cr, Pb and Ni tissue concentrations in the killifish tissue were lower than measured for the other biota (Table 4).

5.0 SUMMARY AND CONCLUSIONS

The objectives of the chemical assessment are:

- Characterization of the metal contaminants associated with the slag and waste material used for the construction of the sea wall and Cheesequake Creek Inlet western jetty;
- Evaluation of the leachability and mobility of metals from the slag and associated waste material under acidic and simulated salt water conditions;
- Assessment of contaminant release through biomonitoring techniques;
- Evaluation of the fate and transport of the metals to environmental media including the soil, pore water and biota of the intertidal zone adjacent to the seawall;
- Collection of data relevant to human health and ecological risk assessments.

The slag originating from the seawall, the Cheesequake Creek Inlet western jetty and the waterfront area west of the jetty was characterized as being quite heterogeneous with a wide range of metal concentrations. Particularly high concentrations were measured for As, Cu, Pb, Sb, Sn and Zn (Table 1a). Lead concentrations exceeded 10,000 mg/kg for 15 of the 17 samples analyzed and exceeded 100,000 mg/kg for 5 of the 17 samples analyzed. Arsenic exceeded 1,000 mg/kg for 13 of the 17 samples analyzed with two of those samples exceeding 10,000 mg/kg. Copper exceeded 1,000 mg/kg for 14 of the 17 slag samples with five samples exceeding 10,000 mg/kg. The highest Cu concentration in the slag was determined at 445,000 mg/kg. Antimony exceeded 1,000 mg/kg for 12 of the 17 slag samples with seven samples exceeding 10,000 mg/kg. Tin exceeded 1,000 mg/kg for 14 of the 17 samples and Zn exceeded 1,000 mg/kg for 13 of the 17 samples (Table 1a). The total metal concentrations found within the slag material support a conclusion that the slag material present, at the Site, constitutes a contaminant source to the surrounding environment.

Compound speciation of the metals associated with the slag identified various Pb, Cu, As and Sn compounds as dominant species (Table 1b). Five different Pb species were identified as dominant species in the slag. Differences in Pb species between exterior and interior slag samples were identified. Analysis of the interior samples, slag that had not been previously exposed to weathering, identified lead carbonate (PbCO_3) as the dominant species for two of the three samples. The dominant species identified for the exterior samples were elemental Pb and PbZrO_3 .

The results of the speciation investigation of the slag material are consistent with a conclusion that the slag is weathering, which would release contamination from the source material.

Leachability and/or mobility of the metal contaminants from the slag were evaluated based on acidic (TCLP) procedures and neutral salt solution extraction. The TCLP protocol provides an assessment of metals potentially being released under exposure to acidic groundwater and/or rainwater conditions, and evaluates the acceptability of the slag for landfill disposal. The TCLP results are given as metal concentrations leached in mg/L to compare results with regulatory limits defined by RCRA and as metals leached in mg/kg dry weight. All 17 slag samples exceeded the 5.0 mg/L RCRA regulatory limit for Pb, with leachable Pb levels ranging from 17 mg/L to 3,140 mg/L. None of the samples exceeded the As regulatory level (Table 3a). The results of the TCLP procedures demonstrate that the slag material fails TCLP and is therefore a hazardous waste.

The TCLP analysis determined that all 17 slag samples leached and/or mobilized Pb at concentrations ranging from 349 mg/kg to 62,700 mg/kg (Table 3b). Leachable Pb exceeded 1,000 mg/kg for 15 of the 17 samples with 10 samples having leachable Pb concentrations exceeding 10,000 mg/kg. The TCLP evaluation also determined that Cu had leached at a concentration of 16,900 mg/kg for the slag that contained the maximum Cu concentration (445,000 mg/kg).

A simulation of the leachability of metals from the slag was also evaluated by exposing the slag to neutral salt solutions. Lead was determined to be leachable and/or mobile from the neutral salt solution exposures with higher levels of leachable Pb determined for the interior (non-weathered) samples compared with the exterior (outer crust) of the slag (Table 3c). The exterior samples had leachable Pb values ranging from 8.3 mg/kg to 10.1 mg/kg, compared to the interior samples with leachable Pb values ranging from 70.9 mg/kg to 870 mg/kg. Weathering of the slag would result in exposing the interior layers of the slag containing more soluble lead species like lead carbonate (PbCO_3). The results of the neutral salt extraction tests demonstrated that contaminants can be released from the slag material under environmental conditions which exist at the Site. In addition the results of these tests are consistent with a conclusion that there is continued weathering of the slag and contaminant release to the surrounding environment.

Soils (*i.e.*, beach sediments) along the entire length of the intertidal zone adjacent to the seawall were characterized by a wide range of concentrations, particularly for Pb, Sb, As and Cu. The wide variations of concentrations are not unexpected since wave action mixes sediments along the shoreline and the physical characteristics of the shoreline create microenvironments. The highest concentrations were 5,860 mg/kg for Pb, 232 mg/kg for Sb, 29 mg/kg for As and 248 mg/kg for Cu (Tables 4 and 5). These results are consistent with a physical and chemical release (weathering) of contaminants from the slag material.

Pore water was analyzed for dissolved metals and total metals. High concentrations of total and dissolved Pb, Mn, As and Sb were measured for the unfiltered and filtered samples (Table 4). The results of the pore water analyses are consistent with a conclusion of release of contaminants from the slag material.

Biomonitoring focused on those organisms residing or utilizing the intertidal zone at this Site that would best assess contaminant release from the seawall. The predominant organisms collected from the intertidal zone included two mollusks (ribbed mussels and juvenile *Mya* clams), the macroalgae (*Ulva*), and the foraging fish (killifish). One mollusk, the hard shell clam, collected within the subtidal zone just beyond the intertidal zone, was also evaluated for its potential to

accumulate metals associated with the Site. In addition, the site investigation revealed that certain organisms that were expected to be present, such as the polychaetes, were essentially absent along the intertidal zone of the seawall. Adult *Mya* clams also were absent during the site investigation along the seawall. The risk to the intertidal fauna and flora at this Site is evaluated in the separate biological assessment report for this project (EPA/ERT/REAC 2009).

Ulva, the sea lettuce, demonstrated the greatest bioaccumulation of metals, particularly for Mn, Pb, As, Cr and Ni (Table 4). Lead had accumulated up to 80 mg/kg in the *Ulva*. The bioaccumulation of metals by *Ulva* would be predominately from exposure to metals in the surface water. The elevated Pb concentrations in the surface water collected from the intertidal zone (See Weston Solutions, Inc 2009) are consistent with the elevated levels of Pb found in the *Ulva*. In addition, the contaminants found with the *Ulva* are consistent with a conclusion of release of contaminants from the slag material.

The juvenile *Mya* clams (less than one year old) had the highest Pb and Cu accumulations compared with the adult ribbed mussels and the adult hard shell clams. Arsenic and Ag were accumulated at comparable concentrations among the three mollusks. Manganese and Zn levels were at the highest levels in the hard shell clam (Table 4). The contaminants found within the bivalves collected at the Site are consistent with a conclusion of release of contaminants from the slag material.

The overall conclusions drawn from the data presented in this report are that the slag and associated debris used for constructing the seawall and building up of the Cheesequake Creek Inlet western jetty provide a significant source of metals to the environment including As, Cu, Pb, Sb, Sn and Zn. Lead is the predominant metal being released. The speciation chemistry performed in conjunction with the leachability testing clearly show that metals, particularly Pb, are in forms that can be released into the environment under conditions which can exist at the Site. The actual release of metals at the site is supported by the findings of metals within the pore water, surface water and soil at the site and is also supported by the bioaccumulation of the Site-related metals by biota residing at the Site.

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Tables 1a and 1b: Total Metal Concentrations and Compound Speciation of Slag Samples
Raritan Bay Slag Site
Old Bridge Township, NJ

Table 1a: Total Metal Concentrations of Slag Samples

Sample ID		356-0001	356-0002	356-0003	356-0004	356-0005	356-0062	356-0063	356-0064	366-0065	356-0066	356-0067	356-0068	356-0069	356-0070	356-0071	356-0072	356-0073
Sample Type		SW-1	SW-2	SW-3	SW-4	SW-5	Jetty 1	Jetty 2A	Jetty 2B	Jetty 3A	Jetty 3B	Jetty 4	Jetty 5	Jetty 6	Jetty 7A	Jetty 7B	W. Jetty 1	W. Jetty 2
		Whole	Whole	Whole	Whole	Whole	Whole	Exterior	Interior	Exterior	Interior	Whole	Whole	Whole	Exterior	Interior	Whole	Whole
Arsenic (As)	mg/kg	9,900	21	2,760	8,390	1,520	8	3,830	4,680	11,340	8,680	91	1,990	6,570	1,630	1,620	15,200	800
Copper (Cu)	mg/kg	20,000	445,000	18,200	9,720	3,370	101	3,200	3,010	10,640	11,600	510	5,190	3,270	8,720	8,360	8,570	250
Lead (Pb)	mg/kg	71,000	675	52,600	79,900	39,600	889	120,000	85,200	82,900	73,300	17,400	131,000	56,000	111,000	116,000	125,000	12,900
Antimony (Sb)	mg/kg	71,300	36	2,950	26,700	2,150	31	46,800	45,200	33,800	34,400	630	6,680	38,200	640	500	5,170	1,320
Tin (Sn)	mg/kg	4,600	25	4,540	9,030	1,830	31	9,580	8,600	7,900	7,730	9,600	7,490	3,000	11,400	10,770	6,640	346
Zinc (Zn)	mg/kg	683	49	13,500	2,750	8,730	1,060	970	1,080	2,570	2,720	9,630	4,520	2,020	9,790	9,650	4,710	385

Table 1b: Dominant Compound Species of Slag Samples Determined by X-ray Diffraction (XRD)

Sample ID	356-0001	356-0002	356-0003	356-0004	356-0005	356-0062	356-0063	356-0064	366-0065	356-0066	356-0067	356-0068	356-0069	356-0070	356-0071	356-0072	356-0073
Sample Type	SW-1	SW-2	SW-3	SW-4	SW-5	Jetty 1	Jetty 2A	Jetty 2B	Jetty 3A	Jetty 3B	Jetty 4	Jetty 5	Jetty 6	Jetty 7A	Jetty 7B	W. Jetty 1	W. Jetty 2
	Whole	Whole	Whole	Whole	Whole	Whole	Exterior	Interior	Exterior	Interior	Whole	Whole	Whole	Exterior	Interior	Whole	Whole
Chemical Formula and Phase ID	FeS - Iron Sulfide	Cu ₂ O-Cuprite	Fe0.985S- Iron Sulfide	FeS- Troilite 2H	FeS- Troilite 2H	SiO ₂ - Quartz	FeS- Troilite 2H	Ba ₂ InSbO ₆ - Ba Sb Indium Oxide	FeS- Iron Sulfide	FeS- Iron Sulfide	Fayalite Magnesian Manganosilicate	Pb(SO ₄)- Lead Sulfate	PbSO ₄ - Anglesite	Fe0.985S- Iron Sulfide	Fe0.985S- Iron Sulfide	Fe0.985S- Iron Sulfide	SiO ₂ - Quartz
	FeS - Troilite-2H	SiO ₂ - Quartz low	FeS- Troilite 2H	SiO ₂ - Quartz	FeS- Iron Sulfide	SiO ₂ - Tridymite	Pb- Lead	FeS- Iron Sulfide	FeS- Troilite 2H	FeS- Troilite 2H	Iron Silicon Oxide	SiO ₂ - Quartz	PbSO ₄ - Anglesite	FeS- Iron Sulfide	FeS- Iron Sulfide	FeS- Iron Sulfide	FeO(OH)- Goethite
	Cobalt-Nickel-Tin	SiO ₂ - Cristobalite	FeO- Iron Oxide	FeS- Iron Sulfide	Fe.9712O- Wuestite	Al ₆ Si ₂ O ₁₃ - Mullite	Co ₃ Sn ₂ - Cobalt Tin	FeS- Troilite 2H	PbZrO ₃ - Lead Zirconium Oxide	FeOOH- Iron Hydroxide Oxide	YBO ₃ - Yttrium Borate	PbSO ₄ - Anglesite	PbO- Litharge	FeS- Troilite 2H	PbCO ₃ - Cerussite	FeS- Troilite 2H	
	CuCO ₃ - Copper Carbonate		Si- Silicon	Fayalite manganosilicate	FeO- Iron Oxide	Fe ₂ O ₃ - Hematite		Iron Cobalt Sulfide	KMg ₃ (Si ₃ Al)O ₁₀ (OH) ₂ - Phlogopite	Co ₃ Sn ₂ - Cobalt Tin	FeS- Iron Sulfide	Chromite	Fe ₃ O ₄ - Magnetite	Mg Zirconium Titanium Oxide	Titanomagnetite	ZnS- Zinc Sulfide	
	FeSb ₂ - Seinaokite			Ni ₂ Y- Nickel Yttrium	Si- Silicon	Iron Tin Oxide		PbCO ₃ - Cerussite	SiO ₂ - Silicon Oxide	ZnSO ₄ - Zinkosite	Zn- Zinc	FeS- Iron Sulfide	NaKZrSi ₃ O ₉ (H ₂ O) ₂ - Georgeckite	SiO ₂ - Quartz	ZnS- Zinc Sulfide	AsCuS- Arsenic Copper Sulfide	
					CuCl- Nantokite	Iron Hydroxide Oxide								Magnetite		KMg ₃ (Si ₃ Al)O ₁₀ (OH) ₂ - Phlogopite	
					Bytownite									Pb- Lead			

mg/kg - milligrams per kilogram
SW - Sea wall
W. Jetty - Westside of Jetty

Tables 2a and 2b: Total Metal Concentrations and Compound Speciation of Soil Samples
Raritan Bay Slag Site
Old Bridge Township, NJ

Table 2a: Total Metal Concentrations of Soil Samples

Sample ID		356-0006	356-0007	356-0008	356-0009	356-0010	356-0048	356-0049	356-0050	356-0051	356-0052
Arsenic (As)	mg/kg	86	43	36	3	9	1,022	122	943	1,980	3,060
Copper (Cu)	mg/kg	123	65	86	5	27	2,050	171	1,290	3,740	6,970
Lead (Pb)	mg/kg	2,580	1,130	2,120	36	96	60,200	2,690	77,200	173,000	147,000
Antimony (Sb)	mg/kg	250	115	92	<5.0	10	3,440	176	4,500	17,600	9,900
Tin (Sn)	mg/kg	113	71	51	4	9	2,020	99	1,340	5,900	5,400
Zinc (Zn)	mg/kg	137	85	65	9	30	2,160	186	1,290	2,300	4,800

Table 2b: Dominant Compound Species of Soil Samples Determined by X-ray Diffraction (XRD)

Sample ID	356-0006	356-0007	356-0008	356-0009	356-0010	356-0048	356-0049	356-0050	356-0051	356-0052
Chemical Formula and Phase ID	SiO ₂ - Quartz low	SiO ₂ - Quartz	SiO ₂ - Quartz	SiO ₂ - Quartz	SiO ₂ - Quartz	SiO ₂ - Quartz	SiO ₂ - Quartz	SiO ₂ - Quartz	SiO ₂ - Quartz	SiO ₂ - Quartz
	CaTiO(SiO ₄)- Titanite	KAlSi ₃ O ₈ - Microcline			Muscovite 2M1	Muscovite 2M2	KAlSi ₃ O ₈ - Microline	PbCO ₃ - Cerussite	Strontium Calcium Sulfide	PbCO ₃ - Cerussite
						PbCO ₃ - Cerussite	Microline, maximum	ZrO ₂ - Zirconium Oxide	PbS- Galena	Pb(SO ₄)- Anglesite
								Barium Manganese Silico	Sodium Nickel Chromium Molybdenum Oxide	Ag(NO ₃)(Ag ₆ O ₈)- Silver Nitrate Oxide
									Pb ₂ OSO ₄ - Lanarkite	CaMgSi ₂ O ₆ - Diopside
									PbCO ₃ - Cerussite	FeS-Iron Sulfide
									AlLiSi- Aluminum Lithium Silicon	FeS-Iron Sulfide
									Pb(OH)Cl- Lead Hydroxide Chloride	Pb(SO ₄)- Lead Sulfate
									PbOHCl- Laurionite	ZrSiO ₄ - Zircon

mg/kg - milligrams per kilogram
Samples 0006 to 0010 Collected along seawall by Weston Solutions, Inc.
Samples 0048 to 0052 collected from beach adjacent to drawbridge by Weston Solutions, Inc.

Tables 3a, 3b and 3c: Leaching Assays using TCLP and Neutral Salt Procedures with Slag Boulders
Raritan Bay Slag Site
Old Bridge Township, NJ

Table 3a: TCLP Assay Results Based on Metals Leached (as mg/L) from Slag Samples

		356-0001	356-0002	356-0003	356-0004	356-0005	356-0062	356-0063	356-0064	356-0065	356-0066	356-0067	356-0068	356-0069	356-0070	356-0071	356-0072	356-0073
Sample ID		SW-1	SW-2	SW-3	SW-4	SW-5	Jetty 1	Jetty 2A	Jetty 2B	Jetty 3A	Jetty 3B	Jetty 4	Jetty 5	Jetty 6	Jetty 7A	Jetty 7B	W. Jetty 1	W. Jetty 2
Sample Type		Whole	Whole	Whole	Whole	Whole	Whole	Exterior	Interior	Exterior	Interior	Whole	Whole	Whole	Exterior	Interior	Whole	Whole
Arsenic (As)	mg/L	0.6	<0.02	0.10	3.6	0.08	<0.02	0.047	0.07	<0.02	0.15	0.17	0.08	0.18	<0.02	<0.02	<0.02	<0.02
Copper (Cu)	mg/L	<0.02	845	0.13	<0.02	<0.02	0.16	<0.02	<0.02	<0.02	0.25	<0.02	<0.02	0.06	<0.02	<0.02	<0.02	0.037
Lead (Pb)	mg/L	143	17	1,170	1,440	702	23	1,340	1,220	586	1,060	137	319	131	3,090	1,970	3,140	103
Antimony (Sb)	mg/L	0.7	0.17	0.07	0.6	0.09	0.16	0.6	0.45	0.06	0.42	0.9	0.6	10.1	<0.02	<0.02	0.05	<0.02
Tin (Sn)	mg/L	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Zinc (Zn)	mg/L	0.6	0.9	12	2.9	50	0.24	0.7	2.8	1.6	2.0	10	6	2.2	19	14	2.1	0.35

Table 3b: TCLP Assay Results Based on Metals Leached (as mg/kg dry weight) from Slag Samples

		356-0001	356-0002	356-0003	356-0004	356-0005	356-0062	356-0063	356-0064	356-0065	356-0066	356-0067	356-0068	356-0069	356-0070	356-0071	356-0072	356-0073
Sample ID		SW-1	SW-2	SW-3	SW-4	SW-5	Jetty 1	Jetty 2A	Jetty 2B	Jetty 3A	Jetty 3B	Jetty 4	Jetty 5	Jetty 6	Jetty 7A	Jetty 7B	W. Jetty 1	W. Jetty 2
Sample Type		Whole	Whole	Whole	Whole	Whole	Whole	Exterior	Interior	Exterior	Interior	Whole	Whole	Whole	Exterior	Interior	Whole	Whole
Arsenic (As)	mg/kg	11.6	<0.4	1.9	72.8	1.6	<0.4	0.9	1.5	<0.4	2.9	3.4	1.7	3.7	<0.4	<0.4	<0.4	<0.4
Copper (Cu)	mg/kg	<0.4	16,900	2.5	<0.4	<0.4	3.1	<0.4	<0.4	<0.4	4.9	<0.4	<0.4	1.1	<0.4	<0.4	<0.4	0.7
Lead (Pb)	mg/kg	2,860	349	23,300	28,750	14,000	464	26,800	24,400	11,700	21,190	2,740	6,380	2,610	61,800	39,500	62,700	2,050
Antimony (Sb)	mg/kg	15.0	3.5	1.4	11.4	1.8	3.1	12.7	9.0	1.2	8.5	17.8	11.1	10.1	<0.4	<0.4	0.9	<0.4
Tin (Sn)	mg/kg	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4
Zinc (Zn)	mg/kg	13	17	241	59	1,005	5	14	56	32	40	209	115	44	385	273	41	7

Table 3c: Neutral Salt Assay Results Based on Metals Leached (as mg/kg dry weight) from Slag Samples

		356-0001	356-0002	356-0003	356-0004	356-0005	356-0062	356-0063	356-0064	356-0065	356-0066	356-0067	356-0068	356-0069	356-0070	356-0071	356-0072	356-0073
Sample ID		SW-1	SW-2	SW-3	SW-4	SW-5	Jetty 1	Jetty 2A	Jetty 2B	Jetty 3A	Jetty 3B	Jetty 4	Jetty 5	Jetty 6	Jetty 7A	Jetty 7B	W. Jetty 1	W. Jetty 2
Sample Type		Whole	Whole	Whole	Whole	Whole	Whole	Exterior	Interior	Exterior	Interior	Whole	Whole	Whole	Exterior	Interior	Whole	Whole
As	mg/kg	<0.1	<0.1	<0.1	0.3	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.2	1.0	<0.1	<0.1	<0.1	<0.1
Cu	mg/kg	0.3	0.4	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Pb	mg/kg	0.2	<0.1	45.0	491	8.1	0.2	8.3	610	1.3	870	10.9	505	72.2	10.1	70.9	2.7	47.5
Sb	mg/kg	11.7	0.1	<0.1	0.161	<0.1	0.5	<0.1	<0.1	<0.1	<0.1	0.3	0.4	1.0	<0.1	<0.1	<0.1	<0.1
Sn	mg/kg	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Zn	mg/kg	<0.1	<0.1	9.6	8.1	2.8	<0.1	<0.1	2.13	<0.1	5.8	9.1	126	64.5	<0.1	23.5	<0.1	1.2

SW - Sea wall
W. Jetty - Westside of Jetty
mg/kg - milligrams per kilogram
mg/L - milligrams per Liter
TCLP - Toxicity Characteristic Leaching Procedure

Table 4. Analytical Results of Biota, Soil* and Pore Water Samples Collected Adjacent to Seawall																						
Raritan Bay Slag Site Old Bridge Township, NJ																						
Sample Description	Sample Location	Units	Antimony (Sb)		Arsenic (As)		Copper (Cu)		Chromium (Cr)		Lead (Pb)		Manganese (Mn)		Nickel (Ni)		Silver (Ag)		Tin (Sn)		Zinc (Zn)	
			Concentration	Qualifier	Concentration	Qualifier	Concentration	Qualifier	Concentration	Qualifier	Concentration	Qualifier	Concentration	Qualifier	Concentration	Qualifier	Concentration	Qualifier	Concentration	Qualifier	Concentration	Qualifier
Pore Water	PW-A1 (Total/Unfiltered)	ug/L	4	U	20	U	80	U	12	U	8	U	840		9.6		4	U	400	U	40	U
	PW-B1 (Total/Unfiltered)	ug/L	2	U	19		40	U	7.6		10		540		6.9		2	U	200	U	20	U
	PW-C1 (Total/Unfiltered)	ug/L	56		71		40	U	9.8		1500		1800		10		2	U	200	U	27	
	PW-D1 (Total/Unfiltered)	ug/L	270		230		91		17		2400		1100		33		2	U	200	U	150	
	PW-E1 (Total/Unfiltered)	ug/L	9.7		39		40	U	7.9		160		2300		5.8		2	U	200	U	20	U
	PW-A2 (Filtered)	ug/L	2	U	11		40	U	6		4	U	840		7.3		2	U	200	U	20	U
	PW-B2 (Filtered)	ug/L	2	U	23		20	U	6.6		2	U	530		4.9		2	U	200	U	20	U
	PW-C2 (Filtered)	ug/L	19		41		20	U	6.6		2	U	1800		6.1		2	U	200	U	20	U
	PW-D2 (Filtered)	ug/L	130		86		40	U	7.1		170		1100		11		2	U	200	U	20	U
PW-E2 (Filtered)	ug/L	4		29		20	U	6.4		2	U	2300		5.5		2	U	200	U	20	U	
Soil* Samples	SS-RM1	mg/kg	0.22		5.6	J	4.4	J+	9		12		22	J	1.6	J+	0.11	U	11	UJ	25	
	SS-RM2	mg/kg	0.31		6.1	J	9.9	J+	9.5		16		44	J	3		0.095	U	9.5	UJ	31	
	SS-RM3	mg/kg	0.49		8.5	J	15		21		19		48	J	2.6		0.089	U	8.9	UJ	33	
	SS-RM4	mg/kg	1.5		6.9	J	11		7.7		94		28	J	2.3	J+	0.08		8	J	40	
	SS-RM5	mg/kg	6.1		13	J	22		18		660		260	J	5.8		0.19		18	J	57	
	SS-RM6	mg/kg	1.6		29	J	17		46		93		99	J	8.5		0.12		9.9	UJ	91	
	SS-MM1	mg/kg	1.1		9.4	J	13		15		47		29	J	5		0.13		8.7	J	68	
	SS-MM2	mg/kg	0.84		15	J	11		37		29		56	J	6.6		0.1	U	10	UJ	91	
	SS-MM3	mg/kg	1.2		5.4	J	31		14		83		19	J	2.9		1.1		14	UJ	53	
	SS-MM4	mg/kg	0.42		12	J	9.4	J+	44		26		55	J	4.9		0.099	U	9.9	UJ	56	
SS-MM5	mg/kg	0.47		7.4	J	7.4	J+	11		24		32	J	2.8		0.087	U	8.7	UJ	44		
Ribbed Mussels	RM-1	mg/kg	0.23	U	7.7		14	J+	2.3		3		5.3	J+	0.54	J+	0.76		23	U	57	
	RM-2	mg/kg	0.24		7.6		16	J+	2		5.1		4.7	J+	0.63	J+	0.71		21	U	64	
	RM-3	mg/kg	0.23		6.1		10.4		1.8		3.3		4.4	J+	0.57	J+	0.38		14	U	41	
	RM-4	mg/kg	0.21	U	7.7		14	J+	2.1		4		6.3	J+	0.62	J+	0.52		21	U	57	
	RM-5	mg/kg	0.19	U	7.7		12	J+	1.3		6		5	J+	0.45	J+	0.48		19	U	53	
	RM-6	mg/kg	0.25		9.5		14.4	J+	1.6		8.6		7.1	J+	0.54	J+	0.38		21	U	59	
Soft Shell Clam (Mya)	Mya-1	mg/kg	0.15	U	1.4		8.5	J+	0.67		3.4		4.3	J+	0.36	J+	0.15	U	15	U	21	
	Mya-2	mg/kg	0.4		7.6		21		1.6		15		30		1.3	J+	0.38		27	U	94	
	Mya-3	mg/kg	0.37		6.4		22		1.6		17		130		1.3	J+	0.7		16	U	96	
	Mya-4	mg/kg	1.2		7.3		31		3.1		16		20		1.4	J+	0.5		12	U	86	
	Mya-5	mg/kg	0.33		7.2		24		1.5		14		21		1.7	J+	0.52		13	U	94	
Hard Shell Clam (Mercenaria)	Mer-1 (Small)	mg/kg	0.11	U	5.1		14		1.8		1.7		52		1.4	J+	0.19		11	U	69	
	Mer-2 (Medium)	mg/kg	0.11	U	5.9		11		1.6		2.9		200		0.95	J+	0.26		11	U	93	
	Mer-3 (Large)	mg/kg	0.1	U	9.8		14.3		1.2		3.1		120		1.6	J+	2.1		10	U	120	
Foraging Fish (Fundulus)	FF-1	mg/kg	0.17	U	3.6		5	J+	1		0.52	J+	13.3		0.34	J+	0.17	U	17	U	80	
	FF-2	mg/kg	0.19	U	3.5		4.8	J+	1		0.92	J+	18		0.39	J+	0.19	U	19	U	93	
	FF-3	mg/kg	0.16	U	3.5		5.9	J+	0.98		0.49	J+	14		0.33	J+	0.16	U	16	U	79	
	FF-4	mg/kg	0.17	U	3.8		6.1	J+	1.1		0.49	J+	17		0.39	J+	0.17	U	17	U	93	
	FF-5	mg/kg	0.29	U	3.7		5	J+	1.3		0.52	J+	15		0.38	J+	0.29	U	29	U	87	
Sea Lettuce (Ulva)	Ulva-1	mg/kg	0.23		4.7		12	J+	5		24		120	J-	2.6	J+	0.19	U	19	U	32	
	Ulva-2	mg/kg	0.6		15		9.7	J+	2.6		56		230	J-	4	J+	0.23	U	23	U	51	
	Ulva-3	mg/kg	0.54		10		11	J+	2.8		66		250	J-	4.7	J+	0.18	U	18	U	41	
	Ulva-4	mg/kg	0.57		12		12	J+	4.6		69		280	J-	3.4	J+	0.2	U	20	U	51	
	Ulva-5	mg/kg	0.75		6.3		13	J+	3.4		80		280	J-	3.6	J+	0.21	U	21	U	38.1	
mg/kg=milligram per kilogram dry weight ug/L=microgram per liter																						
U=Undetected J+= Value is estimated high																						
J= Estimated UJ= Not detected and reporting limit is estimated																						
* Soil = Beach Sediments																						

mg/kg=milligram per kilogram dry weight
ug/L=microgram per liter

U=Undetected
J+= Value is estimated high

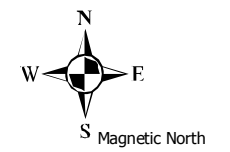
J= Estimated
UJ= Not detected and reporting limit is estimated

* Soil = Beach Sediments

Table 5. Analytical Results of Soil^a Samples Collected Along Intertidal Zone Adjacent to Seawall*
Raritan Bay Slag Site
Old Bridge Township, NJ

Sample	Distance from Seawall (ft)	Units	Antimony (Sb)		Arsenic (As)		Copper (Cu)		Chromium (Cr)		Lead (Pb)		Manganese (Mn)		Nickel (Ni)		Silver (Ag)		Tin (Sn)		Zinc (Zn)	
			Concentration	Qualifier	Concentration	Qualifier	Concentration	Qualifier	Concentration	Qualifier	Concentration	Qualifier	Concentration	Qualifier	Concentration	Qualifier	Concentration	Qualifier	Concentration	Qualifier	Concentration	Qualifier
RBS-SED17	75	mg/kg	8.5	R	2.4	R	10.2	R	4.9		75.7		16.8	R	1.3	J	1.4	U	14.2	UJ	27.6	J
RBS-SED18	75	mg/kg	3.1	R	5.6	R	18.6	R	8.3		186		46.8	R	2.7	J	1.6	U	16	UJ	52.7	J
RBS-SED07	25	mg/kg	232	R	157	R	248	R	57		5860		174	R	18.4		0.24	J	127	J	242	J
RBS-SED08	25	mg/kg	20.9	R	22.7	R	24	R	7.1		861		48.5	R	3	J	1.3	U	38.6	J	46.3	J
RBS-SED19	75	mg/kg	2.1	R	6.3	R	11	R	9.1		93.5		43.1	R	3.2	J	1.5	U	15	UJ	43.2	J
RBS-SED09	25	mg/kg	15.1	R	17.1	R	31.1	R	17.3		403		65.9	R	2.7	J	1.2	U	14.5	J	47	J
RBS-SED20	75	mg/kg	0.58	R	9.4	R	27.1	R	19.6		58.2		40.8	R	7.4		1.5	U	15.2	UJ	59.2	J
RBS-SED21	75	mg/kg	0.46	R	2	R	7.4	R	5.7		48.1		17.4	17.4	1.2	J	1.3	U	13.1	UJ	32.2	J
RBS-SED22	75	mg/kg	7.7	UJ	2.4		8.4		6.4		53.6	J	18.7		5.2	U	0.32	J	12.9	UJ	34.9	
RBS-SED10	25	mg/kg	7.6	R	9.5	R	18.1	R	7.4		326		51.7	R	3.2	J	1.2	U	12.4	UJ	41.1	J
RBS-SED23	75	mg/kg	8.6	UJ	3.1		9.6		5.5		90.7	J	17.2		5.7	U	0.22	J	14.3	UJ	30.3	
RBS-SED11	25	mg/kg	15.1	R	12.5	R	51.7	R	8.1		441		29.5	R	4.4	J	1.4	U	47.8	J	53.8	J
RBS-SED24	75	mg/kg	8.3	UJ	2.9		9.7		6		79.4	J	14.6		5.5	U	1.4	U	13.8	UJ	32.9	
RBS-SED12	25	mg/kg	26	R	29.4	R	31.8	R	10.4		660		23.4	R	5.8		1.2	U	53.6	J	54.9	J
RBS-SED25	75	mg/kg	13.9	J	6.6		21.2		4.5		458	J	15.5		4.7	U	1.2	U	22.5		29.1	
RBS-SED26	25	mg/kg	20.5	J	15.7		25.4		6.3		525	J	89.5		5.6	U	1.4	U	1020		39.4	
RBS-SED88	75	mg/kg	28	J	19.2		117		5.8		1440	J	13.7		5.6	U	0.14	J	42.1		53.2	
RBS-SED87	25	mg/kg	33.2	J	22.5		37.3		6.7		1100	J	51.6		12.2		0.23	J	45.4		41.1	

* Data from Weston Solutions 2009
a. Soil = Beach Sediments
U= Undetected analyte
J= Estimated concentration
UJ - The analyte was not quantifiable at or above the Contract Required Quantitation Limit (CRQL), or QA/QC requirements were not met
R= Unusable value



Legend

Sampling Locations

- MYA 1 to 5
- RM 1 to 6
- ULVA 1 to 5
- Mercenaria 1 to 3
- Killifish 1 to 5



Map created using New Jersey 2007 color orthophotography , site GPS survey data.

Map Creation Date: 18 May 2009

Coordinate system: New Jersey State Plane

FIPS: 2900.

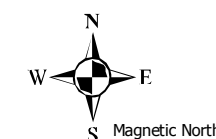
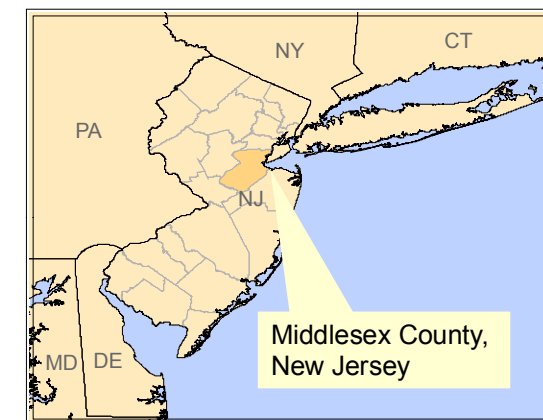
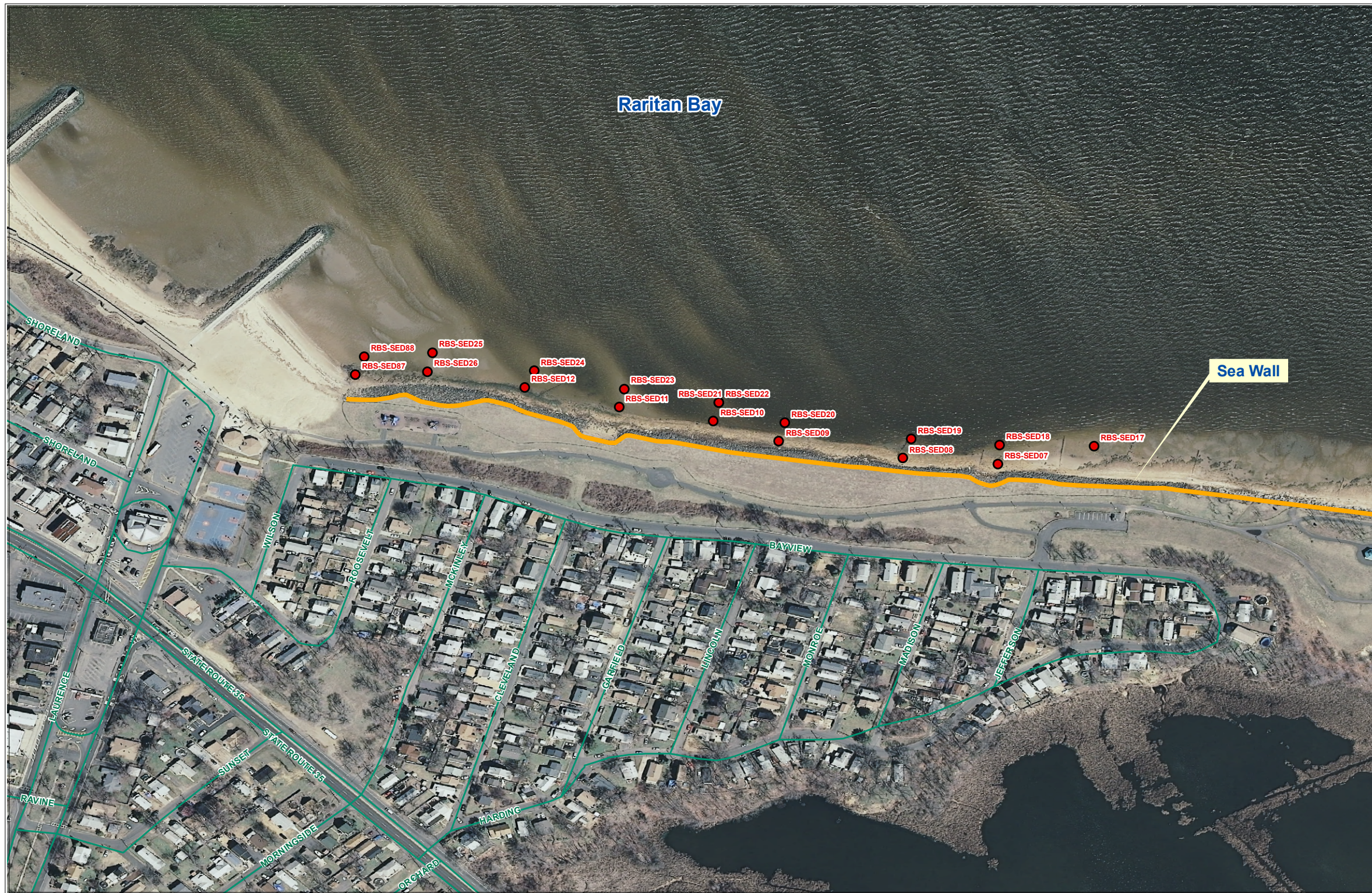
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Revision Number: 002

U.S EPA Environmental Response Team
Response Engineering and Analytical Contract
EP-C-04-032
W.A.# 0-356

Figure 2
Sampling Locations
Raritan Bay Slag Site
Old Bridge Township, New Jersey
May, 2009



Legend

- Sample Location
- Sea Wall

Map created using New Jersey 2007 color orthophotography , site GPS survey data.

Map Creation Date: 18 May 2009

Coordinate system: New Jersey State Plane
 FIPS: 2900.
 Datum : NAD83.
 Units : Feet.



Data: g:\arcviewprojects\reac4\00-356
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 Revision Number: 001

U.S EPA Environmental Response Team
 Response Engineering and Analytical Contract
 EP-C-04-032
 W.A.# 0-356

Figure 3
 Soil Sampling Location
 Raritan Bay Slag Site
 Old Bridge Township, New Jersey
 May, 2009



Figure 4: Intertidal Zone Along Seawall



Figure 5: Seawall Slag at High Tide



Figure 6: Cheesequake Creek Inlet Western Jetty at High Tide



Figure 7: Cheesequake Creek Inlet Western Jetty



Figure 8: Slag at Cheesequake Creek Inlet
Western Jetty



Figure 9: Slag and Fragments



Figure 10: Beachfront Area West of Jetty



Figure 11: *Spartina* (Cordgrass) Along Seawall at
Low Tide



Figure 12: Ribbed Mussels



Figure 13: *Mya* (Steamer) Clam

APPENDIX A

ANALYTICAL REPORT: CHARACTERIZATION OF SLAG

OHIO STATE UNIVERSITY

Raritan Bay Slag and Soil Characterizations

E.A. Dayton, S.D. Whitacre
School of Environment and Natural Resources
The Ohio State University
March, 2009

Project Summary:

Seventeen waste rock samples and ten sediment samples were characterized for As, Pb, Cu, Sn, Zn, and Sb. Elemental content was determined for all twenty-seven samples, while solubility and leachability were determined on only the seventeen waste rock samples. Additional spectroscopic investigation was performed on all twenty-seven samples in order to identify possible mineral phases in the waste rock and sediment.

The twenty-seven samples varied widely in elemental content (Table 1), indicating that the Raritan Bay waste rock and sediment contaminant concentrations are very heterogeneous.

Table 1. Minimum (min), maximum (max), and median elemental content of Raritan Bay waste rock and sediment (US EPA 3051A).

Element	Unit	min	max	median
As	g/kg	0.00313	15.2	1.62
Cu	g/kg	0.00477	445	3.27
Pb	g/kg	0.0358	173	60.2
Sb	g/kg	0.00976	71.3	3.19
Sn	g/kg	0.00416	11.4	4.54
Zn	g/kg	0.00917	13.5	2.02

Methods:

The samples were oven dried at 60°C followed by pulverization to powder in a puck mill and homogenization. Elemental content was determined by US EPA method 3051A (SOP attached); solubility was determined with a neutral salt (0.01M CaCl₂) extraction (SOP attached); and leachability by the toxicity characteristic leaching procedure (SOP attached). Particle size of the powdered samples was further reduced using an agate mortar and pestle prior to X-ray diffraction (XRD). The XRD analysis was carried out using a Scintag XDS2000 diffractometer equipped with a θ - θ goniometer, a 2kW sealed-beam tube with Cu anode and Si-Ge solid-state detector. Samples were pressed into Plexiglas specimen mounts and scanned according to the instrumental settings given in Table 2. The raw scans were collected using the Scintag DMS2000 Diffraction Management Software (Sunnyvale, CA).

Table 2. X-ray diffractometer settings

Scan range	2-80°2 θ
Tube voltage	45kV
Filament current	20mA
Source collimating slits	2 & 4mm
Detector receiving slits	0.5 & 0.3mm
Scan mode	continuous
Scan rate	1°min ⁻¹
Scan interval	0.03°2 θ

Pattern processing and phase identification were carried out using MDI (Materials Data Inc., Livermore, CA) Jade ver. 6.1 (preferences given in Table 3 below). A background function was fitted and subtracted from each of the raw scans. Phase identification by search/match routine was launched on the reduced pattern.

Table 3. Peak Search and Background Fitting Preferences

Peak Search Filter Points	15
Peak Search Filter Type	Parabolic
Peak Location	by summit
K α ₂ peaks	screened out
Threshold sigma	3.0
Intensity cutoff %	0.10
Background fitting function	cubic spline
Background fitting point sampling	dense
Background fitting vertical offset	0.4

The Powder Diffraction File (PDF) maintained by the International Center for Diffraction Data (ICDD) & the Inorganic Crystal Structure Database (ICSD) which include NBS and common phases were accessed during the search/match routine. A preferred orientation filter was invoked to compensate for particle orientations acquired during packing of the specimen holder. A 2θ error window of 0.06 and 2θ position and intensity matching sensitivities of 4 and 6 respectively were used. Phases were sorted by figure of merit and selected/rejected based on visual match to the pattern. Phase selections were further guided by results from the dissolution chemistry.

Tables 1 to 4 provide the results.

Table 1: Total Elemental Content of Slag and Soil Samples
Raritan Bay Slag Site
Old Bridge Township, NJ

		356-0001	356-0002	356-0003	356-0004	356-0005	356-0062	356-0063	356-0064	366-0065	356-0066	356-0067	356-0068	356-0069	356-0070	356-0071	356-0072	356-0073
Sample ID		SW-1	SW-2	SW-3	SW-4	SW-5	Jetty 1	Jetty 2A	Jetty 2B	Jetty 3A	Jetty 3B	Jetty 4	Jetty 5	Jetty 6	Jetty 7A	Jetty 7B	W. Jetty 1	W. Jetty 2
Sample Type		Whole	Whole	Whole	Whole	Whole	Whole	Exterior	Interior	Exterior	Interior	Whole	Whole	Whole	Exterior	Interior	Whole	Whole
As	g/kg	9.90	0.0214	2.76	8.39	1.52	0.00774	3.83	4.68	11.3	8.68	0.0907	1.99	6.57	1.63	1.62	15.2	0.801
Cu	g/kg	20.0	445	18.2	9.72	3.37	0.101	3.20	3.01	10.6	11.6	0.511	5.19	3.27	8.72	8.36	8.57	0.253
Pb	g/kg	71.0	0.675	52.6	79.9	39.6	0.889	120	85.2	82.9	73.3	17.4	131	56.0	111	116	125	12.9
Sb	g/kg	71.3	0.0360	2.95	26.7	2.15	0.0313	46.8	45.2	33.8	34.4	0.628	6.68	38.2	0.637	0.502	5.17	1.32
Sn	g/kg	4.61	0.0249	4.54	9.03	1.83	0.0307	9.58	8.60	7.90	7.73	9.60	7.49	3.00	11.4	10.8	6.64	0.346
Zn	g/kg	0.683	0.0493	13.5	2.75	8.73	1.06	0.974	1.08	2.57	2.72	9.63	4.52	2.02	9.79	9.65	4.71	0.385

		356-0006	356-0007	356-0008	356-0009	356-0010	356-0048	356-0049	356-0050	356-0051	356-0052
Sample ID											
Sample Type											
As	g/kg	0.0865	0.0426	0.0356	0.00313	0.00875	1.02	0.122	0.943	1.98	3.06
Cu	g/kg	0.123	0.0653	0.0862	0.00477	0.0274	2.05	0.171	1.29	3.74	6.97
Pb	g/kg	2.58	1.13	2.12	0.0358	0.0962	60.2	2.69	77.2	173	147
Sb	g/kg	0.250	0.115	0.0918	<0.005	0.00976	3.44	0.176	4.49	17.6	9.88
Sn	g/kg	0.113	0.0706	0.0515	0.00416	0.00893	2.02	0.0989	1.34	5.94	5.40
Zn	g/kg	0.137	0.0854	0.0646	0.00917	0.0296	2.16	0.186	1.29	2.30	4.79

U.S. EPA method 3051a
SW - Sea wall
W. Jetty - Westside of Jetty

Table 2: X-ray Diffraction Results
Raritan Bay Slag Site
Old Bridge Township, NJ

356-0001		
Phase ID	Chemical Formula	File ID
[x] Iron Sulfide	FeS	PDF#65-3356
[x] Troilite-2H	FeS	PDF#37-0477
[x] Tin Arsenide	Sn4As3	PDF#74-0256
[x] Cobalt Nickel Tin	Co0.75Ni0.75Sn0.75	PDF#27-1119
[x] Copper Carbonate	CuCO3	PDF#70-2053
[x] Seinajokite, syn	FeSb2	PDF#80-1925
356-0002		
Phase ID	Chemical Formula	File ID
[x] Cuprite	Cu2O	PDF#78-2076
[x] Quartz low	SiO2	PDF#86-1630
[x] Cristobalite, syn	SiO2	PDF#39-1425
356-0003		
Phase ID	Chemical Formula	File ID
[x] Iron Sulfide	Fe0.985S	PDF#80-1030
[x] Troilite 2H	FeS	PDF#75-2165
[x] Iron Oxide	FeO	PDF#89-0687
[x] Silicon	Si	PDF#77-2108
356-0004		
Phase ID	Chemical Formula	File ID
[x] Troilite 2H	FeS	PDF#75-2165
[x] Quartz	SiO2	PDF#75-0443
[x] Iron Sulfide	FeS	PDF#65-0408
[x] Fayalite manganoan	(Mg.028Fe.908Mn.064)(Mg.028Fe.892Mn.057Ca.023)(SiO4)	PDF#87-0676
[x] Nickel Yttrium	Ni2Y	PDF#65-3043
356-0005		
Phase ID	Chemical Formula	File ID
[x] Troilite-2H	FeS	PDF#37-0477
[x] Iron Sulfide	FeS	PDF#65-0408
[x] Wuestite, syn	Fe.9712O	PDF#74-1884
[x] Iron Oxide	FeO	PDF#89-0687
[x] Silicon	Si	PDF#78-2500
[x] Nantokite, syn	CuCl	PDF#77-2383
356-0006		
Phase ID	Chemical Formula	File ID
[x] Quartz low	SiO2	PDF#86-1560
[x] Titanite	CaTiO(SiO4)	PDF#87-0125
356-0007		
Phase ID	Chemical Formula	File ID
[x] Quartz \$GA, syn	SiO2	PDF#78-1253
[x] Microcline maximum	KAlSi3O8	PDF#76-0918
356-0008		
Phase ID	Chemical Formula	File ID
[x] Quartz \$GA, syn	SiO2	PDF#78-1253
356-0009		
Phase ID	Chemical Formula	File ID
[x] Quartz	SiO2	PDF#85-0794
356-0010		
Phase ID	Chemical Formula	File ID
[x] Quartz	SiO2	PDF#85-0794
[x] Muscovite 2M1	(Na0.37K0.60)(Al1.84Ti0.02Fe0.10Mg0.06)(Si3.03Al0.97)O10	PDF#85-2147

Table 2 Continued: X-ray Diffraction Results
Raritan Bay Slag Site
Old Bridge Township, NJ

356-0048		
Phase ID	Chemical Formula	File ID
[x] Quartz	SiO2	PDF#85-0794
[x] Muscovite-2M2	K0.77Al1.93(Al0.5Si3.5)O10(OH)2	PDF#70-1869
[x] Cerussite	PbCO3	PDF#76-2056
356-0049		
Phase ID	Chemical Formula	File ID
[x] Quartz	SiO2	PDF#85-0794
[x] Microcline, intermediate	KAlSi3O8	PDF#19-0932
[x] Microcline maximum	(K.95Na.05)AlSi3O8	PDF#84-1455
356-0050		
Phase ID	Chemical Formula	File ID
[x] Quartz	SiO2	PDF#85-0794
[x] Cerussite, syn	PbCO3	PDF#47-1734
[x] Zirconium Oxide	ZrO2	PDF#79-1796
[x] Barium Manganese Silicon	BaMnSi2	PDF#65-2400
356-0051		
Phase ID	Chemical Formula	File ID
[x] Quartz	SiO2	PDF#85-0794
[x] Strontium Calcium Sulfide	Sr.75Ca.25S	PDF#75-0265
[x] Galena, syn	PbS	PDF#05-0592
[x] Sodium Nickel Chromium Molybdenum O	NaNi3Cr(MoO4)5	PDF#52-1721
[x] Lanarkite, syn	Pb2OSO4	PDF#72-1393
[x] Cerussite	PbCO3	PDF#76-2056
[x] Aluminum Lithium Silicon	AlLiSi	PDF#65-3003
[x] Lead Hydroxide Chloride	Pb(OH)Cl	PDF#89-0623
[x] Laurionite	PbOHCl	PDF#74-2022
356-0052		
Phase ID	Chemical Formula	File ID
[x] Quartz	SiO2	PDF#79-1906
[x] Cerussite, syn	PbCO3	PDF#70-2052
[x] Anglesite	Pb(SO4)	PDF#83-1720
[x] Silver Nitrate Oxide	Ag(NO3)(Ag6O8)	PDF#71-0904
[x] Diopside	CaMgSi2O6	PDF#86-0932
[x] Iron Sulfide	FeS	PDF#65-3356
[x] Iron Sulfide	FeS	PDF#65-0408
[x] Lead Sulfate	Pb(SO4)	PDF#82-1855
[x] Zircon	ZrSiO4	PDF#75-1590
356-0062		
Phase ID	Chemical Formula	File ID
[x] Quartz \$GA, syn	SiO2	PDF#78-1253
[x] Tridymite	SiO2	PDF#71-0261
[x] Mullite, syn	Al6Si2O13	PDF#15-0776
[x] Hematite	Fe2O3	PDF#87-1164
[x] Iron Tin Oxide	Fe1.727Sn0.205O3	PDF#88-0434
[x] Iron Hydroxide Oxide	Fe1.833(OH)0.5O2.5	PDF#76-0182
[x] Bytownite	Ca0.86Na0.14Al1.84Si2.16O8	PDF#76-0832
356-0063		
Phase ID	Chemical Formula	File ID
[x] Troilite 2H	FeS	PDF#75-2165
[x] Lead, syn	Pb	PDF#04-0686
[x] Cobalt Tin	Co3Sn2	PDF#27-1124

Table 2 Continued: X-ray Diffraction Results
Raritan Bay Slag Site
Old Bridge Township, NJ

356-0064		
Phase ID	Chemical Formula	File ID
[x] Barium Antimony Indium Oxide	Ba2InSbO6	PDF#52-0005
[x] Iron Sulfide	FeS	PDF#65-3356
[x] Troilite-2H	FeS	PDF#37-0477
[x] Iron Cobalt Sulfide	Fe.92Co.08S	PDF#79-0597
[x] Cerussite, syn	PbCO3	PDF#47-1734
356-0065		
Phase ID	Chemical Formula	File ID
[x] Iron Sulfide	FeS	PDF#65-0408
[x] Troilite 2H	FeS	PDF#75-2165
[x] Lead Zirconium Oxide	PbZrO3	PDF#49-0011
[x] Phlogopite-2M1	KMg3(Si3Al)O10(OH)2	PDF#10-0493
[x] Silicon Oxide	SiO2	PDF#82-1561
356-0066		
Phase ID	Chemical Formula	File ID
[x] Iron Sulfide	FeS	PDF#65-3356
[x] Troilite 2H	FeS	PDF#75-2165
[x] Iron Hydroxide Oxide	FeOOH	PDF#70-0714
[x] Cobalt Tin	Co3Sn2	PDF#27-1124
[x] Zinkosite, syn [NR]	ZnSO4	PDF#08-0491
356-0067		
Phase ID	Chemical Formula	File ID
[x] Fayalite magnesian manganoean	Mg.105Fe1.741Mn.121SiO4	PDF#88-2000
[x] Iron Silicon Oxide	Fe2.35Si0.65O4	PDF#52-1143
[x] Yttrium Borate	YBO3	PDF#74-1929
[x] Iron Sulfide	FeS	PDF#65-3356
[x] Zinc, syn	Zn	PDF#04-0831
356-0068		
Phase ID	Chemical Formula	File ID
[x] Lead Sulfate	Pb(SO4)	PDF#82-1854
[x] Quartz	SiO2	PDF#87-2096
[x] Anglesite, syn	PbSO4	PDF#36-1461
[x] Chromite	(Mg0.43Fe0.58)8(Cr1.19Al0.77Ti0.03)8O32	PDF#72-2493
[x] Iron Sulfide	FeS	PDF#65-3356
356-0069		
Phase ID	Chemical Formula	File ID
[x] Anglesite	Pb(SO4)	PDF#83-1720
[x] Anglesite	Pb(SO4)	PDF#83-1720
[x] Litharge, syn	PbO	PDF#85-1739
[x] Magnetite	Fe3O4	PDF#75-0449
[x] Georgechaoite	NaKZrSi3O9(H2O)2	PDF#84-0922
356-0070		
Phase ID	Chemical Formula	File ID
[x] Iron Sulfide	Fe0.985S	PDF#80-1030
[x] Iron Sulfide	FeS	PDF#65-0408
[x] Troilite-2H	FeS	PDF#37-0477
[x] Magnesium Zirconium Titanium Oxide	Mg.25Zr.38Ti.38O1.75	PDF#77-2164
[x] Quartz	SiO2	PDF#79-1915
[x] Magnetite, syn	Fe2.964O4	PDF#87-0244

Table 2 Continued: X-ray Diffraction Results
Raritan Bay Slag Site
Old Bridge Township, NJ

356-0071		
Phase ID	Chemical Formula	File ID
[x] Iron Sulfide	Fe0.985S	PDF#80-1030
[x] Iron Sulfide	FeS	PDF#65-0408
[x] Cerussite, syn	PbCO3	PDF#70-2052
[x] Titanomagnetite	Al0.7Cr0.3Fe17.485Mg0.4Mn0.114O32Si0.06Ti4.72V0.15	PDF#74-2034
[x] Zinc Sulfide	ZnS	PDF#89-2181
356-0072		
Phase ID	Chemical Formula	File ID
[x] Iron Sulfide	Fe0.985S	PDF#80-1030
[x] Iron Sulfide	FeS	PDF#65-3356
[x] Troilite-2H	FeS	PDF#37-0477
[x] Zinc Sulfide	ZnS	PDF#89-2144
[x] Arsenic Copper Sulfide	AsCuS	PDF#65-1505
[x] Phlogopite-2M1	KMg3(Si3Al)O10(OH)2	PDF#10-0493
356-0073		
Phase ID	Chemical Formula	File ID
[x] Quartz	SiO2	PDF#85-0794
[x] Goethite, syn	FeO(OH)	PDF#81-0462

Table 3a: Toxicity Characteristic Leaching Procedure (TCLP) for Slag Collected from Sea Wall, Jetty and Westside of Jetty (mg/kg)
Raritan Bay Slag Site
Old Bridge Township, NJ

		356-0001	356-0002	356-0003	356-0004	356-0005	356-0062	356-0063	356-0064	356-0065	356-0066	356-0067	356-0068	356-0069	356-0070	356-0071	356-0072	356-0073
Sample ID		SW-1	SW-2	SW-3	SW-4	SW-5	Jetty 1	Jetty 2A	Jetty 2B	Jetty 3A	Jetty 3B	Jetty 4	Jetty 5	Jetty 6	Jetty 7A	Jetty 7B	W. Jetty 1	W. Jetty 2
Sample Type		Whole	Whole	Whole	Whole	Whole	Whole	Exterior	Interior	Exterior	Interior	Whole	Whole	Whole	Exterior	Interior	Whole	Whole
As	mg/kg	11.6	<0.4	1.9	72.8	1.6	<0.4	0.9	1.5	<0.4	2.9	3.4	1.7	3.7	<0.4	<0.4	<0.4	<0.4
Cu	mg/kg	<0.4	16,896	2.5	<0.4	<0.4	3.1	<0.4	<0.4	<0.4	4.9	<0.4	<0.4	1.1	<0.4	<0.4	<0.4	0.7
Pb	mg/kg	2,860	349	23,333	28,753	14,044	464	26,816	24,393	11,714	21,191	2,743	6,377	2,612	61,755	39,487	62,713	2,054
Sb	mg/kg	15.0	3.5	1.4	11.4	1.8	3.1	12.7	9.0	1.2	8.5	17.8	11.1	10.1	<0.4	<0.4	0.9	<0.4
Sn	mg/kg	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4
Zn	mg/kg	12.9	17.3	241.1	58.9	1,004.6	4.8	14.2	56.2	31.9	40.4	209.0	115.2	44.3	384.6	273.3	41.2	7.0

SW - Sea wall
W. Jetty - Westside of Jetty
mg/kg - milligrams per kilogram

Table 3b: Toxicity Characteristic Leaching Procedure (TCLP) for Slag Collected from Sea Wall, Jetty and Westside of Jetty (mg/L)
Raritan Bay Slag Site
Old Bridge Township, NJ

		356-0001	356-0002	356-0003	356-0004	356-0005	356-0062	356-0063	356-0064	356-0065	356-0066	356-0067	356-0068	356-0069	356-0070	356-0071	356-0072	356-0073
Sample ID		SW-1	SW-2	SW-3	SW-4	SW-5	Jetty 1	Jetty 2A	Jetty 2B	Jetty 3A	Jetty 3B	Jetty 4	Jetty 5	Jetty 6	Jetty 7A	Jetty 7B	W. Jetty 1	W. Jetty 2
Sample Type		Whole	Whole	Whole	Whole	Whole	Whole	Exterior	Interior	Exterior	Interior	Whole	Whole	Whole	Exterior	Interior	Whole	Whole
As	mg/L	0.6	<0.02	0.10	3.6	0.08	<0.02	0.047	0.07	<0.02	0.15	0.17	0.08	0.18	<0.02	<0.02	<0.02	<0.02
Cu	mg/L	<0.02	845	0.13	<0.02	<0.02	0.16	<0.02	<0.02	<0.02	0.25	<0.02	<0.02	0.06	<0.02	<0.02	<0.02	0.037
Pb	mg/L	143	17	1,167	1,438	702	23	1,341	1,220	586	1,060	137	319	131	3,088	1,974	3,136	103
Sb	mg/L	0.7	0.17	0.07	0.6	0.09	0.16	0.6	0.45	0.06	0.42	0.9	0.6	10.1	<0.02	<0.02	0.05	<0.02
Sn	mg/L	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Zn	mg/L	0.6	0.9	12	2.9	50	0.24	0.7	2.8	1.6	2.0	10	6	2.2	19	14	2.1	0.35

Table 4: Leachability of Slag Exposed to 0.01M Calcium Chloride (CaCl₂) Solution
Raritan Bay Slag Site
Old Bridge Township, NJ

		356-0001	356-0002	356-0003	356-0004	356-0005	356-0062	356-0063	356-0064	356-0065	356-0066	356-0067	356-0068	356-0069	356-0070	356-0071	356-0072	356-0073
Sample ID		SW-1	SW-2	SW-3	SW-4	SW-5	Jetty 1	Jetty 2A	Jetty 2B	Jetty 3A	Jetty 3B	Jetty 4	Jetty 5	Jetty 6	Jetty 7A	Jetty 7B	W. Jetty 1	W. Jetty 2
Sample Type		Whole	Whole	Whole	Whole	Whole	Whole	Exterior	Interior	Exterior	Interior	Whole	Whole	Whole	Exterior	Interior	Whole	Whole
As	mg/kg	<0.1	<0.1	<0.1	0.341	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.163	1.02	<0.1	<0.1	<0.1	<0.1
Cu	mg/kg	0.290	0.398	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Pb	mg/kg	0.181	<0.1	45.0	491	8.14	0.173	8.27	610	1.27	870	10.9	505	72.2	10.1	70.9	2.75	47.5
Sb	mg/kg	11.7	0.123	<0.1	0.161	<0.1	0.542	<0.1	<0.1	<0.1	<0.1	0.290	0.362	0.974	<0.1	<0.1	<0.1	<0.1
Sn	mg/kg	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Zn	mg/kg	<0.1	<0.1	9.60	8.08	2.79	<0.1	<0.1	2.13	<0.1	5.76	9.10	126	64.5	<0.1	23.5	<0.1	1.22

SW - Sea wall
W. Jetty - Westside of Jetty
mg/kg - milligrams per kilogram

Standard Operating Procedure
3051a Microwave Assisted Acid Digestion of Sediments, Sludges, and Soils
Followed by Inductively Coupled Plasma (ICP) Spectrometry analysis
Soil Environmental Chemistry Program, The Ohio State University
Version 2

1.0 Scope of Method

- 1.1 This method is a microwave-assisted extraction using aqua regia and HNO_3 . This method is more aggressive in dissolving the sample matrix than methods using conventional heating with nitric acid (HNO_3), or alternatively, nitric acid and hydrochloric acid (HCl), according to EPA Methods 200.2 and 3050. However, because Method 3051a does not accomplish total decomposition of the sample, the extracted analyte concentrations may not reflect the total content in samples where the analytes are occluded in recalcitrant mineral phases. This method is applicable to the microwave-assisted acid extraction/dissolution† of sediments, sludges, and soils, for the following elements: Aluminum (Al)*, Antimony (Sb)*, Arsenic (As), Barium (Ba)*, Beryllium (Be)*, Boron (B), Cadmium (Cd), Calcium (Ca), Chromium (Cr)*, Cobalt (Co), Copper (Cu), Iron (Fe)*, Lead (Pb), Magnesium (Mg)*, Manganese (Mn), Molybdenum (Mo), Nickel (Ni), Potassium (K), Selenium (Se), Silver (Ag)*, Sodium (Na), Strontium (Sr), Thallium (Tl), Vanadium (V)*, Zinc (Zn).

*Indicates elements which typically require the addition of HCl to achieve equivalent results with EPA Method 3050, as noted in reference 3.

This method is intended to provide a rapid multi-element acid extraction or dissolution prior to analysis. Many types of samples will be dissolved by this method. A few refractory sample matrix compounds, such as quartz, silicates, titanium dioxide, alumina, and other oxides may not be dissolved and in some cases may sequester target analyte elements. These bound elements are considered non-mobile in the environment and are excluded from most aqueous transport mechanisms of pollution.

2.0 Definitions

- 2.1 Laboratory Control Sample: The laboratory control used for the microwave digestion is a standard reference material (SRM) or certified reference material (CRM) that goes through the same extraction/preparation procedure as the samples. The analyte composition of the laboratory control sample is certified by acid dissolution method 3051a, 3050, or equivalent.
- 2.2 Duplicate Samples: A duplicate test involves splitting a sample two sub-samples and processing each through the same sample preparation procedure in order to determine the precision of the method.
- 2.3 Pre-digestion Spike: A duplicate sample is spiked prior to digestion in order to provide information about the effect of the sample matrix on the digestion and/or measurement methodology.
- 2.4 Preparation Blank: The Preparation Blank is a sample that contains only the reagents used in the extraction procedure. The preparation blanks is processed

Standard Operating Procedure
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through the same preparation procedures as the samples and therefore gives an indication of any contamination picked up during the sample preparation process.

2.5 Serial Dilution: A serial dilution consists of a comparison of the results of a sample and another aliquot diluted by a known factor.

2.6 ICP-AES: Inductively Coupled Plasma-Atomic Emission Spectrometry.

2.7 ICP-HG-AES: ICP-AES with sample introduction using automated hydride generation

2.8 ICP-MS: Inductively Coupled Plasma-Mass Spectrometry.

3.0 Equipment and Supplies

3.1 MARS 1600 watt microwave (CEM corporation, Mathews, NC).

Note: The microwave power output test, power calibration, and temperature probe calibration should be performed according to manufactures specifications every six months.

3.2 Trace metal grade nitric acid.

3.3 Trace metal grade hydrochloric acid.

3.4 ≥ 18 M Ω deionized water (DI).

3.5 50ml volumetric flasks

3.6 Parafilm

4.0 Procedure

Review SOP for handling acids (attached) prior to beginning the procedure.

4.1 Weigh a well-mixed sample to the nearest 0.001 g into an acid washed Teflon vessel equipped with a controlled pressure relief mechanism.

4.2 Add 9.0 ± 0.1 mL concentrated nitric acid and 3.0 ± 0.1 mL concentrated hydrochloric acid to the vessel in a fume hood.

4.2a The addition of concentrated hydrochloric acid to the nitric acid is appropriate for the stabilization of certain analytes, such as Ag, Ba, and Sb and high concentrations of Fe and Al in solution.

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- 4.3 Seal the vessel according to the manufacturer's directions. Properly place the vessel in the microwave system according to the manufacturer's recommended specifications.
- 4.4 Enable the appropriate 3051 method in the MARS unit software as determined by the number of samples and project requirements. Note: The 3051_40 express method does not adhere to the 4 minute ramp requirement of the USEPA 3051 method.
- 4.5 Once the digests have cooled, remove from the microwave and wholly transfer into labeled 50ml volumetrics that have been acid washed following the *Dish Washing SOP* and triple rinsed with ≥ 18 M Ω DI water immediately prior to transfer.
- 4.6 Bring samples to volume, cover with parafilm and mix thoroughly by inversion. Bring to volume and mix thoroughly again after samples have cooled.
- 4.7 Syringe filter samples into labeled falcon tubes using dry acid washed syringes and nylon 0.45um nylon syringe filters.

5.0 Quality Control

- 5.1 Laboratory Control Sample: The laboratory control sample must fall within $\pm 20\%$ of the known value or within the 95% prediction interval of the certified value. The laboratory control sample must be run with each batch of microwave digestions.
- 5.2 Sample Duplicates: The relative percent difference (RPD) must be no more than 20%. One sample duplicate must be run with every microwave batch.

$$RPD = 100 \times \frac{|S - D|}{\text{Avg. (S,D)}}$$

- 5.3 Pre-digestion Spike: Spike recoveries must fall within the limits of 75-125%. At least one spike analyses (matrix spikes) shall be performed on each group of samples of a similar matrix type. Pre-digestion spikes are to be done at the following levels for elements of interest.

Final Spike concentration	mg/L spike solution	uL spike prior to digest
As - 400 mg/kg	1000	200
Ba - 400 mg/kg	1000	200
Se 400 mg/kg	1000	200
Tl - 400 mg/kg	1000	200
Sb - 100 mg/kg	1000	50
Co 100 mg/kg	1000	50

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Pb - 100 mg/kg	1000	50
Mn - 100 mg/kg	1000	50
Ni - 100mg/kg	1000	50
V - 100 mg/kg	1000	50
Zn - 100 mg/kg	1000	50
Cu 50 mg/kg	1000	25
Cr 40 mg/kg	1000	20
Ag - 10 mg/kg	100	50
Be - 10 mg/kg	100	50
Cd 10 mg/kg	100	50

5.4 Preparation Blank: If any analyte concentration is above the detection limit, in the preparation blank, the lowest concentration of the analyte reported in associated samples must be ≥ 10 times the preparation blank concentration. A preparation blank must be performed with each batch of microwave digests.

5.5 Serial Dilution: The % difference for the serial dilution tests must be no more than 10%. At least one serial dilutions should be performed on each group of samples with similar matrix.

$$\% \text{Difference} = 100 * \frac{[\text{initial}] - ([\text{diluted}] * \text{DilutionFactor})}{[\text{initial}]}$$

6.0 Instrumental Analysis

6.1 Instrumentation: ICP-AES and ICP-HG-AES analysis are carried out on a Varian Vista-MPX ICP-OES (Varian Inc., Walnut Creek, CA). Determination by ICP-MS is done on a Perkin-Elmer Sciex ELAN 6000 (Perkin-Elmer Inc., Waltham, MA)

6.2 Detection Limits

6.2a Method detection limits (MDL) are calculated for specific methods and consequent conditions of that method developed for analysis on ICP. The method detection limit is determined by multiplying by 3.143 the standard deviation of seven replicate analyses of standard solutions at 2-5x the IDL limit.

6.3 Stock standards are prepared using ICP grade standards (SPEX CertiPrep Group, Metuchen, NJ, Assurance ICP Standards). Calibration standards are prepared daily by serial dilution from at least two independent stock standards. The dilutions should be done into a matrix comparable to the samples.

6.4 Nebulizer optimization should be performed before each calibration. Nebulizer optimization should be carried out according to manufacturer specifications.

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- 6.5 Instruments shall be calibrated daily and each time the instrument is set up. Calibrate the instrument according to instrument manufacturer's recommended procedures. At least four standards shall be used for ICP calibration. One of the standards shall be a blank. Linear calibration must meet the criteria of: $r^2 = 0.995$, and calculated concentrations from the regression within 10% for each standard in the calibration.
- 6.6 Initial calibration verification (ICV) is an independent certified mixed QC standard (SPEX CertiPrep Group LPC standard 1, Fisher Cat. No. LPC-1-100N) run immediately after instrument calibration. Standards must fall within $\pm 10\%$ of certified value. An independent standard is defined as a standard composed of the analytes from a different source than those used in the standards for the instrument calibration.
- 6.7 Continuing calibration verification (CCV) is a dilution of the ICV QC standard and is run after every ten samples. Standards must fall within $\pm 10\%$ of certified value.
- 6.8 Initial calibration blank (ICB) is a calibration blank run just prior to the first sample. The calibration blank must fall below the method detection limit (MDL) detection limit. If the calibration blank is above the MDL, the problem should be fixed and instrument re-calibrated.
- 6.9 Continuing calibration blank (CCB) is a calibration blank run after every ten samples with the CCV. The calibration blank must fall below the MDL. If a calibration blank is above the detection limit, the instrument must be recalibrated and the previous samples to the last CCB re-run.
- 6.10 Limit of quantitation (LOQ) is a check standard used to verify linearity at the MDL for ICP analysis. The LOQ standards at a concentration equal to the MDL are analyzed at the beginning and end of each sample analysis and at a frequency of not greater than 20 analytical samples.
- 6.11 A linear range verification check standard shall be analyzed for each wavelength concentrations that exceed the highest calibration standard by more than 20%. The standard shall be analyzed during the analytical run. The analytically determined concentration of this standard shall be within 10% of the true value. This concentration is the upper limit of the ICP linear range beyond which results cannot be reported without dilution of the analytical sample.
- 6.12 Potential interferences are determined by calibration of all potential lines used for analysis followed by the analysis of single element standards as samples containing 10 to 500mg/L. Interferences were identified as a signal greater than the IDL on any line other than the element in the standard. The single element standards

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investigated included; Al, As, B, Ba, Be, Ca, Cd, Co, Cr, Cu, Fe, K, Mg, Mn, Mo, Na, Ni, P, Pb, Sb, Se, Ti, V, Zn.

6.13 To verify interelement and background correction factors for the ICP, an Interference Check Samples (ICS) shall be analyzed at the beginning and end of each analysis run and not greater than 20 analytical samples per analysis run. The Interference Check Samples consist of two solutions: Solution A and Solution AB. Solution A consists of the interferents, and Solution AB consists of the analytes mixed with the interferents. An ICS analysis consists of analyzing both solutions consecutively (starting with Solution A) for all wavelengths used for each analyte reported by ICP. The analytical results for those target analytes with MDLs < 10 ug/L shall fall within + 2x MDL of the analyte's true value (the true value shall be zero unless otherwise stated) in the ICS Solution A (ICSA). For example, if the analysis result(s) for Arsenic (MDL = 10 ug/L, ICSA true value = 0 ug/L) in the ICSA analysis during the run is + 19 ug/L, then the analytical result for Arsenic falls within the + 2x MDL window for Arsenic in the ICSA. Results for the ICP analyses of Solution AB during the analytical runs shall fall within the control limit of +20% of the true value for the analytes included in the Interference Check Samples. If not, terminate the analysis, correct the problem, recalibrate the instrument, and reanalyze the analytical samples analyzed since the last good ICS. This + 20% window does not apply when the IDL exceeds the MDL for the analytes As, Pb, Se, Ti.

INTERFERENT AND ANALYTE ELEMENTAL CONCENTRATIONS USED FOR ICP
INTERFERENCE CHECK SAMPLE

Analytes (mg/L)		Interferents (mg/L)
ICS B		ICS A & ICS B
Se 0.05	Ti 0.1	Al 500
As 0.1	Zn 1.0	Ca 500
Ba 0.5		Fe 200
Be 0.5		Mg 500
Cd 1.0		
Co 0.5		
Cr 0.5		
Cu 0.5		
Mn 0.5		
Ni 1.0		
Pb 0.05		

7.0 Reporting

7.1 If the QC limits are not met for any element or sample, the effect on the data set will be evaluated by the project manager and analyst.

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8.0 References

- 8.1 United States Environmental Protection Agency. Method 3051A. Microwave assisted acid digestion of sediments, sludges, soils, and oils. In SW-846; U.S. EPA: Washington, DC, 1998.
- 8.2 United States Environmental Protection Agency. Method 6010C. Inductively Coupled Plasma-Atomic Emission Spectrometry. In SW-846; U.S. EPA: Washington, DC, 2007.
- 8.3 United States Environmental Protection Agency. Method 6020A. Inductively Coupled Plasma-Atomic Mass Spectrometry. In SW-846; U.S. EPA: Washington, DC, 2007.
- 8.4 United States Environmental Protection Agency. Document number ILM04.0b. Contract Laboratory Program Statement of work for inorganic analysis, multi-media, multi-concentration. U.S. EPA: Washington, DC.

Standard Operating Procedure
Neutral Salt Extraction
Soil and Environmental Chemistry Group, The Ohio State University, Version 2

1.0 Scope of Method

- 1.1 A neutral salt extraction is used to screen for elemental solubility.
- 1.2 This method is applicable for testing soil, sediments, and municipal/industrial byproducts

3.0 Definitions

- 2.1 Duplicate Samples: A duplicate test involves splitting a sample into two or more sub-samples and processing each through the same sample preparation procedure in order to determine the precision of the method.
- 2.2 Preparation Blank: A sample that contains only the reagents used in the extraction procedure. The preparation blank is processed through the same procedures as samples and therefore gives an indication of potential contamination- in the sample preparation process.
- 2.3 ICP-AES: Inductively Coupled Plasma-Atomic Emission Spectrometry.

3.0 Equipment and Supplies

- 3.1 Shaker
- 3.2 Neutral salt solution
- 3.4 ≥ 18 M Ω deionized water.

4.0 Procedure

- 4.1 Samples should be oven dried 70 °C, dried and crushed to < 2 mm
- 4.2 Weigh 5 g of well-mixed sample to the nearest 0.001 g into a 50 mL centrifuge tube
- 4.3 Add 25 mL of 0.01 M CaCl₂ solution and cap vessel
- 4.4 Equilibrate sample by shaking for 4h
- 4.5 Filter (0.45 μ m) using nylon syringe filters, into ICP falcon tubes
- 4.6 Refrigerate filtered extracts and analyze within 2 days or add 1 drop concentrated HCl to preserve samples.

5.0 Quality Control

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5.1 Sample Duplicates: The % relative standard deviation (%RPD) must be no more than 20%. One sample duplicate must be run for every twenty samples.

$$RPD = 100 \times \frac{|S - D|}{\text{Avg. (S,D)}}$$

5.2 Preparation Blank: If any analyte concentration is above the detection limit, the lowest concentration of the analyte in the associated samples must be 10 times the preparation blank concentration. A preparation blank must run every 10 samples

6.0 Instrumental Analysis by ICP-OES

6.1 Instrumentation: ICP-AES and ICP-HG-AES analysis are carried out on a Varian Vista-MPX ICP-OES (Varian Inc., Walnut Creek, CA).

6.2 Stock standards are prepared using ICP grade standards (SPEX CertiPrep Group, Metuchen, NJ, Assurance ICP Standards). Calibration standards are prepared daily by serial dilution from at least two independent stock standards. The dilutions should be done into a matrix comparable to the samples.

6.3 Nebulizer optimization should be performed before each calibration. Nebulizer optimization should be carried out according to manufacturer specifications.

6.4 Instruments shall be calibrated daily and each time the instrument is set up. Calibrate the instrument according to instrument manufacturer's recommended procedures. At least four standards shall be used for ICP calibration. One of the standards shall be a blank. Linear calibration must meet the criteria of: $r^2 = 0.995$, and calculated concentrations from the regression within 10% for each standard in the calibration.

6.5 Initial calibration verification (ICV) is an independent certified mixed QC standard (SPEX CertiPrep Group LPC standard 1, Fisher Cat. No. LPC-1-100N) run immediately after instrument calibration. Standards must fall within $\pm 10\%$ of certified value. An independent standard is defined as a standard composed of the analytes from a different source than those used in the standards for the instrument calibration.

6.6 Continuing calibration verification (CCV) is a dilution of the ICV QC standard and is run after every ten samples. Standards must fall within $\pm 10\%$ of certified value.

6.7 Initial calibration blank (ICB) is a calibration blank run just prior to the first sample. The calibration blank must fall below the method detection limit (MDL) detection limit. If the calibration blank is above the MDL, the problem should be fixed and instrument re-calibrated.

6.8 Continuing calibration blank (CCB) is a calibration blank run after every ten samples with the CCV. The calibration blank must fall below the MDL. If a calibration blank is above

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Neutral Salt Extraction

Soil and Environmental Chemistry Group, The Ohio State University, Version 2

the detection limit, the instrument must be recalibrated and the previous samples to the last CCB re-run.

- 6.9 Limit of quantitation (LOQ) is a check standard used to verify linearity at the MDL for ICP analysis. The LOQ standards at a concentration equal to the MDL are analyzed at the beginning of each sample analysis.
- 6.10 A linear range verification check standard shall be analyzed for each wavelength concentrations that exceed the highest calibration standard by more than 20%. The standard shall be analyzed during the analytical run. The analytically determined concentration of this standard shall be within 10% of the true value. This concentration is the upper limit of the ICP linear range beyond which results cannot be reported without dilution of the analytical sample
- 6.11 Potential interferences are determined by calibration of all potential lines used for analysis followed by the analysis of single element standards as samples containing 10 to 500mg/L. Interferences were identified as a signal greater than the IDL on any line other than the element in the standard. The single element standards investigated included; Al, As, B, Ba, Be, Ca, Cd, Co, Cr, Cu, Fe, K, Mg, Mn, Mo, Na, Ni, P, Pb, Sb, Se, Ti, V, Zn.

7.0 Reporting

- 7.1 If the QC limits are not met for any element or sample, the effect on the data set will be evaluated by the project manager and analyst.

8.0 References

- 8.1 U.S. Environmental Protection Agency. Method 6010C. Inductively Coupled Plasma-Atomic Emission Spectrometry. In SW-846; U.S. EPA: Washington, DC, 2007.
- 8.2 U.S. Environmental Protection Agency. Document number ILM04.0b. Contract Laboratory Program Statement of work for inorganic analysis, multi-media, multi-concentration. U.S. EPA: Washington, DC.

Toxicity Characteristic Leaching Procedure (TCLP) for Inorganics
Standard Operating Procedure
Soil Environmental Chemistry Program, The Ohio State University
Version 1

1.0 Scope of Method

1.1 The TCLP is designed to determine the mobility of both organic and inorganic analytes present in liquid, solid, and multiphasic wastes.

2.0 Definitions

2.1 Duplicate Samples: A duplicate test involves splitting a sample two sub-samples and processing each through the same sample preparation procedure in order to determine the precision of the method.

2.2 Preparation Blank: The Preparation Blank is a sample that contains only the reagents used in the extraction procedure. The preparation blanks is processed through the same preparation procedures as the samples and therefore gives an indication of any contamination picked up during the sample preparation process.

2.3 Matrix Spike: A duplicate sample is spiked after to the extraction procedure in order to provide information about the effect of the sample matrix on the measurement methodology.

2.4 ICP-AES: Inductively Coupled Plasma-Atomic Emission Spectrometry.

3.0 Equipment and Supplies

3.1 Agitation apparatus

3.2 high density polyethylene (HDPE), polypropylene (PP), or polyvinyl chloride(PVC) extraction vessels

3.3 pH Meter accurate to 0.05 units

3.4 Laboratory Balance: Any laboratory balance accurate to within + 0.01 grams may be used (all weight measurements are to be within + 0.1 grams).

3.5 Hydrochloric acid (1N), HCl, made from ACS reagent grade.

3.6 Nitric acid (1N), HNO₃, made from ACS reagent grade.

3.7 Sodium hydroxide (1N), NaOH, made from ACS reagent grade.

3.8 Glacial acetic acid, CH₃CH₂OOH, ACS reagent grade.

3.9 ≥18 MΩ deionized water (DI).

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3.10 Parafilm

4.0 Procedure

Review SOP for handling acids (attached) prior to beginning the procedure.

4.1 Oven dry sample at 60°C.

4.2 Grind solid sample until it is capable of passing through a 9.5 mm sieve.

4.3 Determine the correct extraction solution for the sample.

4.3.1 Weigh 5g of sample into a 500 mL beaker or Erlenmeyer flask. Add 96.5 mL of reagent water to the beaker, cover with a watchglass, and stir vigorously for 5 minutes using a magnetic stirrer. Measure and record the pH. If the pH is <5.0, use extraction fluid #1. If the pH from Section 7.1.4.2 is >5.0, add 3.5 mL 1N HCl, slurry briefly, cover with a watchglass, heat to 50 °C, and hold at 50 EC for 10 minutes. Let the solution cool to room temperature and record the pH. If the pH is <5.0, use extraction fluid #1. If the pH is >5.0, use extraction fluid #2.

4.4 Prepare appropriate extraction solution.

Extraction fluid # 1: Add 5.7 mL glacial $\text{CH}_3\text{CH}_2\text{OOH}$ to 500 mL of reagent water (See Section 5.2), add 64.3 mL of 1N NaOH, and dilute to a volume of 1 liter. When correctly prepared, the pH of this fluid will be 4.93 ± 0.05 .

Extraction fluid # 2: Dilute 5.7 mL glacial $\text{CH}_3\text{CH}_2\text{OOH}$ with reagent water (See Section 5.2) to a volume of 1 liter. When correctly prepared, the pH of this fluid will be 2.88 ± 0.05

4.5 Weigh 1.5g of sample into extraction vessel.

4.6 Add 30ml of extraction fluid

4.7 Close the extractor bottle tightly, secure in agitation device, and agitate for 18 ± 2 hours.

4.8 Remove from rotary agitation device and 0.45um nylon syringe filter (aprox. 12ml) into falcon tubes for ICP analysis. Samples should be preserved <pH 2 by the addition of 1 drop of concentrated HNO_3 .

5.0 Instrumental Analysis by ICP-OES

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- 5.1 Instrumentation: ICP-AES and ICP-HG-AES analysis are carried out on a Varian Vista-MPX ICP-OES (Varian Inc., Walnut Creek, CA). Determination by ICP-MS is done on a Perkin-Elmer Sciex ELAN 6000 (Perkin-Elmer Inc., Waltham, MA)
- 5.2 Stock standards are prepared using ICP grade standards (SPEX CertiPrep Group, Metuchen, NJ, Assurance ICP Standards). Calibration standards are prepared daily by serial dilution from at least two independent stock standards. The dilutions should be done into a matrix comparable to the samples.
- 5.3 Nebulizer optimization should be performed before each calibration. Nebulizer optimization should be carried out according to manufacturer specifications.
- 5.4 Instruments shall be calibrated daily and each time the instrument is set up. Calibrate the instrument according to instrument manufacturer's recommended procedures. At least four standards shall be used for ICP calibration. One of the standards shall be a blank. Linear calibration must meet the criteria of: $r^2 = 0.995$, and calculated concentrations from the regression within 10% for each standard in the calibration.
- 5.5 Initial calibration verification (ICV) is an independent certified mixed QC standard (SPEX CertiPrep Group LPC standard 1, Fisher Cat. No. LPC-1-100N) run immediately after instrument calibration. Standards must fall within $\pm 10\%$ of certified value. An independent standard is defined as a standard composed of the analytes from a different source than those used in the standards for the instrument calibration.
- 5.6 Continuing calibration verification (CCV) is a dilution of the ICV QC standard and is run after every ten samples. Standards must fall within $\pm 10\%$ of certified value.
- 5.7 Initial calibration blank (ICB) is a calibration blank run just prior to the first sample. The calibration blank must fall below the method detection limit (MDL) detection limit. If the calibration blank is above the MDL, the problem should be fixed and instrument re-calibrated.
- 5.8 Continuing calibration blank (CCB) is a calibration blank run after every ten samples with the CCV. The calibration blank must fall below the MDL. If a calibration blank is above the detection limit, the instrument must be recalibrated and the previous samples to the last CCB re-run.
- 5.9 Limit of quantitation (LOQ) is a check standard used to verify linearity at the MDL for ICP analysis. The LOQ standards at a concentration equal to the MDL are analyzed at the beginning of each sample analysis.

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5.10 A linear range verification check standard shall be analyzed for each wavelength concentrations that exceed the highest calibration standard by more than 20%. The standard shall be analyzed during the analytical run. The analytically determined concentration of this standard shall be within 10% of the true value. This concentration is the upper limit of the ICP linear range beyond which results cannot be reported without dilution of the analytical sample

5.11 Potential interferences are determined by calibration of all potential lines used for analysis followed by the analysis of single element standards as samples containing 10 to 500mg/L. Interferences were identified as a signal greater than the IDL on any line other than the element in the standard. The single element standards investigated included; Al, As, B, Ba, Be, Ca, Cd, Co, Cr, Cu, Fe, K, Mg, Mn, Mo, Na, Ni, P, Pb, Sb, Se, Tl, V, Zn.

6.0 Quality Control

6.1 Sample Duplicates: The relative percent difference (RPD) must be no more than 20%. One sample duplicate must be run every 20 samples.

$$RPD = 100 \times \frac{|S - D|}{\text{Avg. (S,D)}}$$

6.2 Matrix Spike: Spikes should be performed such that the end concentration is within the linear range for the instrument. Spike recoveries for analytes of interest must fall within the limits of 75-125%. At least one spike analyses (matrix spikes) shall be performed on each group of samples of a similar matrix type.

6.3 Preparation Blank: If any analyte concentration is above the LOQ, in the preparation blank, the lowest concentration of the analyte reported in associated samples must be ≥ 10 times the preparation blank concentration. A preparation blank must be performed with each batch of microwave digests.

7.0 Reporting

7.1 If the QC limits are not met for any element or sample, the effect on the data set will be evaluated by the project manager and analyst.

8.0 References

8.1 United States Environmental Protection Agency. Method 1311. Toxicity Characteristic Leaching Procedure. In SW-846; U.S. EPA: Washington, DC, 2007.

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- 8.2 United States Environmental Protection Agency. Method 6010C. Inductively Coupled Plasma-Atomic Emission Spectrometry. In SW-846; U.S. EPA: Washington, DC, 2007.
- 8.3 United States Environmental Protection Agency. Document number ILM04.0b. Contract Laboratory Program Statement of work for inorganic analysis, multi-media, multi-concentration. U.S. EPA: Washington, DC.

APPENDIX B

ANALYTICAL REPORT: SOIL, PORE WATER AND BIOTA

ANALYTICAL REPORT

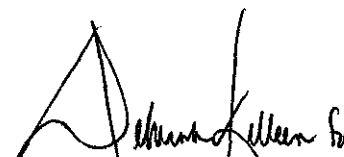
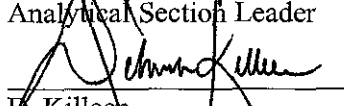
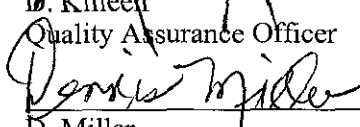
Prepared by
LOCKHEED MARTIN, Inc.

Laurence Harbor Site
Laurence Harbor, NJ

November 2008

EPA Work Assignment No. 0-356
LOCKHEED MARTIN Work Order EAC000356
EPA Contract No. EP-C-04-032

Submitted to
M. Sprenger
EPA-ERT

 V. Kansa Analytical Section Leader	11/3/08 Date
 B. Killeen Quality Assurance Officer	11/3/08 Date
 D. Miller Program Manager	11/3/08 Date

Analysis by:
Katahdin

Prepared by:
Y. Mehra

Reviewed by:
J. Soroka

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Section III

Communication
Chains of Custody

Appendices

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Appendices will be furnished on request.

Introduction

REAC, in response to WA# 0-356, provided analytical support for environmental samples collected from the Laurence Harbor Site in Laurence Harbor, New Jersey, as described in the following table. The support also included QA/QC, data review, and preparation of an analytical report containing the results and the QA/QC results.

Chain of Custody #	Number of Samples	Sampling Date	Date Received	Matrix	Analysis / Method	Lab	Data Package
356-09/15/08-0003	6	09/10/08	9/19/08	Tissue	TAL Metals/ SW-846 6020	Katahdin	T 304
356-09/15/08-0004	5						
356-09/15/08-0005	3	09/11/08					
356-09/15/08-0006	5	09/10/08					
356-09/15/08-0007	5						
356-09/24/08-0009	12	09/11/08	09/25/08	Sediment			T 308
	10	09/22/08		Pore Water			

¹ Katahdin is NELAC certified for Metals analysis.

Case Narrative

The metals data are reported to two significant figures and reported as received from the laboratory. Any other representation of the data is the responsibility of the user. All data validation flags have been inserted into the results tables.

Due to the high levels of acid used during the digestion procedure for ICP-MS metals, all samples underwent a five-fold dilution before analysis. All RLs have been adjusted for dilution.

Metals in Tissue Package T 304

Manganese and copper were detected in the continuing calibration blank (CCB) of 10/2/08-23:44 above the RL. Manganese and copper are qualified estimated high (J+) for the method blank of 10/2/08 and the CO₂ blank.

Copper and lead were detected in the method blank 10/1/08 above the RL. Copper and lead are qualified estimated high (J+) for samples 356-0037 through -0041.

Barium, copper, manganese and nickel were detected in the CO₂ blank above the RL. Barium, copper, manganese and nickel are qualified estimated high (J+) for samples 356-0023, -0024, -0026, -0027, -0028 and -0029. Barium, manganese and nickel are qualified estimated high (J+) for sample 356-0025. Barium and nickel are qualified estimated high (J+) for samples 356-0030, -0031, -0032, -0033, -0034, -0035, and -0036. Barium, copper and nickel are qualified estimated high (J+) for samples 356-0037, -0038, -0039, -0040, -0041, -0042, -0043, -0044, -0045 and -0046.

Aluminum did not meet the %D criterion for the serial dilution analysis of sample 356-0023. Aluminum is qualified estimated (J) for samples 356-0023 through -0041.

Aluminum and manganese did not meet the % recovery criterion for the MS/MSD of sample 356-0043.

Aluminum is qualified estimated high (J+) and manganese estimated low (J-) for samples 356-0042 through -0046.

Metals in Sediment and Water Package T 308

The sediment blank (356-0022) contained aluminum, barium, chromium, copper, lead, manganese and nickel above the reporting limit. Barium is qualified estimated high (J+) for samples 356-0011, -0012, -0013, -0017, -0018 and -0021. Copper is qualified estimated high (J+) for samples 356-0011, -0012, -0020 and -0021. Manganese is qualified estimated high (J+) for samples 356-0011, -0014, -0017, -0019 and -0021. Nickel is qualified estimated high (J+) for samples 356-0011 and -0014.

Manganese and tin did not meet the %RPD criterion for the MS/MSD analysis of sample 356-0011. Manganese did not meet the % recovery criterion for the MS and tin did not meet the % recovery criterion for the MSD of sample 356-0011. Manganese and tin are qualified estimated (J) for samples 356-0011 through -0022.

Arsenic did not meet the %D criterion for the serial dilution analysis of sample 356-0011. Arsenic is qualified estimated (J) for sample 356-0011 through 356-0022.

Summary of Abbreviations

BFB	Bromofluorobenzene
C	Centigrade
CLP	Contract Laboratory Program
COC	Chain of Custody
conc	concentration
cont	continued
CRDL	Contract Required Detection Limit
CRQL	Contract Required Quantitation Limit
D	(Surrogate Table) value is from a diluted sample and was not calculated
Dioxin	Polychlorinated dibenzo-p-dioxins (PCDD) and Polychlorinated dibenzofurans (PCDF)
DFTPP	Decafluorotriphenylphosphine
EMPC	Estimated maximum possible concentration
GC/MS	Gas Chromatography/ Mass Spectrometry
IS	Internal Standard
LCS	Laboratory Control Sample
LCSD	Laboratory Control Sample Duplicate
MDA	Minimum Detectable Activity
MS (BS)	Matrix Spike (Blank Spike)
MSD (BSD)	Matrix Spike Duplicate (Blank Spike Duplicate)
MW	Molecular Weight
NA	Not Applicable or Not Available
NAD	Normalized Absolute Difference
NC	Not Calculated
NR	Not Requested/Not Reported
NS	Not Spiked
% D	Percent Difference
% REC	Percent Recovery
SOP	Standard Operating Procedure
ppbv	parts per billion by volume
ppm	parts per million
pptv	parts per trillion by volume
PQL	Practical Quantitation Limit
QA/QC	Quality Assurance/Quality Control
QL	Quantitation Limit
REAC	Response Engineering and Analytical Contract
RL	Reporting Limit
RPD	Relative Percent Difference
RSD	Relative Standard Deviation
SIM	Selected Ion Monitoring
Sur	Surrogate
TIC	Tentatively Identified Compound
TCLP	Toxicity Characteristic Leaching Procedure
VOC	Volatile Organic Compound
*	Value exceeds the acceptable QC limits.

m ³	cubic meter	g	gram	kg	kilogram	L	liter
μg	microgram	μL	microliter	mg	milligram	mL	milliliter
ng	nanogram	pg	picogram	pCi	picocurie	s	sigma

Data Validation Flags

J	Value is estimated	R	Value is unusable
J+	Value is estimated high (metals only)	U	Not detected
J-	Value is estimated low (metals only)	UJ	Not detected and RL is estimated

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Table 1.1 Results of the Analysis for Metals in Tissue
WA # 356 Laurence Harbor Site
Results are Based on Dry Weight

Method : SW846 6020

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Sample Number	10/1/2008		356-0023		356-0024		356-0025		356-0026	
Sample Location	Method Blank		RM-1		RM-2		RM-3		RM-4	
Percent Solids	--		8.7		9.0		13		8.6	
	Result	RL	Result	RL	Result	RL	Result	RL	Result	RL
Analyte	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg
Aluminum	U	30	U	70	U	62	48	42	U	64
Antimony	U	0.10	U	0.23	0.24	0.21	0.23	0.14	U	0.21
Arsenic	U	0.50	7.7	1.2	7.6	1.0	6.1	0.69	7.7	1.1
Barium	U	0.10	0.60	J+ 0.23	0.66	J+ 0.21	0.46	J+ 0.14	0.48	J+ 0.21
Beryllium	U	0.10	U	0.23	U	0.21	U	0.14	U	0.21
Cadmium	U	0.10	0.83	0.23	0.94	0.21	0.48	0.14	0.74	0.21
Chromium	U	0.30	2.3	0.70	2.0	0.62	1.8	0.42	2.1	0.64
Cobalt	U	0.10	0.28	0.23	0.31	0.21	0.22	0.14	0.31	0.21
Copper	0.63	0.10	14	J+ 0.23	16	J+ 0.21	10	0.14	14	J+ 0.21
Lead	0.12	0.10	3.0	0.23	5.1	0.21	3.3	0.14	4.0	0.21
Manganese	U	0.10	5.3	J+ 0.23	4.7	J+ 0.21	4.4	J+ 0.14	6.3	J+ 0.21
Nickel	U	0.10	0.54	J+ 0.23	0.63	J+ 0.21	0.57	J+ 0.14	0.62	J+ 0.21
Selenium	U	0.50	2.6	1.2	2.4	1.0	1.4	0.69	2.4	1.1
Silver	U	0.10	0.76	0.23	0.71	0.21	0.38	0.14	0.52	0.21
Thallium	U	0.20	U	0.46	U	0.41	U	0.28	U	0.43
Tin	U	10	U	23	U	21	U	14	U	21
Vanadium	U	0.50	U	1.2	1.8	1.0	1.2	0.69	U	1.1
Zinc	U	1.0	57	2.3	64	2.1	41	1.4	57	2.1

Table 1.1 (cont) Results of the Analysis for Metals in Tissue
WA # 356 Laurence Harbor Site
Results are Based on Dry Weight

Method : SW846 6020

Sample Number	356-0027		356-0028		356-0029		356-0030		356-0031	
Sample Location	RM-5		RM-6		Mya-1		Mya-2		Mya-3	
Percent Solids	10		9.4		12		13		12	
	Result	RL	Result	RL	Result	RL	Result	RL	Result	RL
Analyte	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg
Aluminum	U	J 58	U	J 62	U	J 45	230	J 81	220	J 48
Antimony	U	0.19	0.25	0.21	U	0.15	0.40	0.27	0.37	0.16
Arsenic	7.7	0.96	9.5	1	1.4	0.75	7.6	1.4	6.4	0.8
Barium	0.41	J+ 0.19	0.50	J+ 0.21	0.75	J+ 0.15	3.8	J+ 0.27	2.9	J+ 0.16
Beryllium	U	0.19	U	0.21	U	0.15	U	0.27	U	0.16
Cadmium	0.58	0.19	0.40	0.21	U	0.15	U	0.27	0.33	0.16
Chromium	1.3	0.58	1.6	0.62	0.67	0.45	1.6	0.81	1.6	0.48
Cobalt	0.28	0.19	0.29	0.21	U	0.15	0.44	0.27	1.0	0.16
Copper	12	J+ 0.19	14	J+ 0.21	8.5	J+ 0.15	21	0.27	22	0.16
Lead	6.0	0.19	8.6	0.21	3.4	0.15	15	0.27	17	0.16
Manganese	5.0	J+ 0.19	7.1	J+ 0.21	4.3	J+ 0.15	30	0.27	130	0.16
Nickel	0.45	J+ 0.19	0.54	J+ 0.21	0.36	J+ 0.15	1.3	J+ 0.27	1.3	J+ 0.16
Selenium	2.5	0.96	2.6	1	U	0.75	2.3	1.4	1.6	0.80
Silver	0.48	0.19	0.38	0.21	U	0.15	0.38	0.27	0.70	0.16
Thallium	U	0.38	U	0.42	U	0.3	U	0.54	U	0.32
Tin	U	19	U	21	U	15	U	27	U	16
Vanadium	U	0.96	1.1	1	U	0.75	2.4	1.4	2.7	0.80
Zinc	53	1.9	59	2.1	21	1.5	94	2.7	96	1.6

Table 1.1 (cont) Results of the Analysis for Metals in Tissue
WA # 356 Laurence Harbor Site
Results are Based on Dry Weight

Method : SW846 6020

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Sample Number	356-0032	356-0033	356-0034	356-0035	356-0036
Sample Location	Mya-4	Mya-5	Mer-1	Mer-2	Mer-3
Percent Solids	15	13	17	17	16
Analyte	Result mg/Kg	RL mg/Kg	Result mg/Kg	RL mg/Kg	Result mg/Kg
Aluminum	200 J 36	190 J 40	U J 34	U J 32	U J 31
Antimony	1.2 0.12	0.33 0.13	U 0.11	U 0.11	U 0.10
Arsenic	7.3 0.59	7.2 0.66	5.1 0.57	5.9 0.53	9.8 0.52
Barium	3.3 J+ 0.12	3.3 J 0.13	0.66 J+ 0.11	0.66 J+ 0.11	0.71 J+ 0.10
Beryllium	U 0.12	U 0.13	U 0.11	U 0.11	U 0.10
Cadmium	0.14 0.12	0.14 0.13	0.82 0.11	1.0 0.11	0.96 0.10
Chromium	3.1 0.36	1.5 0.40	1.8 0.34	1.6 0.32	1.2 0.31
Cobalt	0.41 0.12	0.44 0.13	0.34 0.11	0.33 0.11	0.79 0.10
Copper	31 0.12	24 0.13	14 0.11	11 0.11	14.3 0.10
Lead	16 0.12	14 0.13	1.7 0.11	2.9 0.11	3.1 0.10
Manganese	20 0.12	21 0.13	52 0.11	200 0.11	120 0.10
Nickel	1.4 J+ 0.12	1.7 J+ 0.13	1.4 J+ 0.11	0.95 J+ 0.11	1.6 J+ 0.10
Selenium	2.0 0.59	2.3 0.66	0.97 0.57	1.3 0.53	1.4 0.52
Silver	0.50 0.12	0.52 0.13	0.19 0.11	0.26 0.11	2.1 0.10
Thallium	U 0.24	U 0.26	U 0.23	U 0.21	U 0.21
Tin	U 12	U 13	U 11	U 11	U 10
Vanadium	2.0 0.59	1.9 0.66	U 0.57	U 0.53	0.55 0.52
Zinc	86 1.2	94 1.3	69 1.1	93 1.1	120 1.0

Table 1.1 (cont) Results of the Analysis for Metals in Tissue
WA # 356 Laurence Harbor Site
Results are Based on Dry Weight

Method : SW846 6020

Sample Number	356-0037	356-0038	356-0039	356-0040	356-0041
Sample Location	FF-1	FF-2	FF-3	FF-4	FF-5
Percent Solids	26	26	27	26	25
Analyte	Result mg/Kg	RL mg/Kg	Result mg/Kg	RL mg/Kg	Result mg/Kg
Aluminum	U J 52	U J 57	U J 48	U J 50	U J 87
Antimony	U 0.17	U 0.19	U 0.16	U 0.17	U 0.29
Arsenic	3.6 0.86	3.5 0.95	3.5 0.80	3.8 0.84	3.7 1.4
Barium	5.1 J+ 0.17	5.9 J+ 0.19	3.2 J+ 0.16	5.7 J+ 0.17	4.7 J+ 0.29
Beryllium	U 0.17	U 0.19	U 0.16	U 0.17	U 0.29
Cadmium	U 0.17	U 0.19	U 0.16	U 0.17	U 0.29
Chromium	1.0 0.52	1.0 0.57	0.98 0.48	1.1 0.50	1.3 0.87
Cobalt	U 0.17	U 0.19	U 0.16	U 0.17	U 0.29
Copper	5.0 J+ 0.17	4.8 J+ 0.19	5.9 J+ 0.16	6.1 J+ 0.17	5.0 J+ 0.29
Lead	0.52 J+ 0.17	0.92 J+ 0.19	0.49 J+ 0.16	0.49 J+ 0.17	0.52 J+ 0.29
Manganese	13 0.17	18 0.19	14 0.16	17 0.17	15 0.29
Nickel	0.34 J+ 0.17	0.39 J+ 0.19	0.33 J+ 0.16	0.39 J+ 0.17	0.38 J+ 0.29
Selenium	1.8 0.86	2.0 0.95	1.8 0.80	2.1 0.84	1.8 1.4
Silver	U 0.17	U 0.19	U 0.16	U 0.17	U 0.29
Thallium	U 0.34	U 0.38	U 0.32	U 0.34	U 0.58
Tin	U 17	U 19	U 16	U 17	U 29
Vanadium	1.1 0.86	1.2 0.95	0.88 0.8	1.1 0.84	U 1.4
Zinc	80 1.7	93 1.9	79 1.6	93 1.7	87 2.9

Table 1.1 (cont) Results of the Analysis for Metals in Tissue
WA # 356 Laurence Harbor Site
Results are Based on Dry Weight

Method : SW846 6020

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Sample Number	10/2/2008		356-0042		356-0043		356-0044		356-0045	
Sample Location	Method Blank		Ulva-1		Ulva-2		Ulva-3		Ulva-4	
Percent Solids	--		19		18		16		18	
	Result	RL	Result	RL	Result	RL	Result	RL	Result	RL
Analyte	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg
Aluminum	U	30	680 J+ 56		480 J+ 69		610 J+ 55		740 J+ 60	
Antimony	U	0.10	0.23	0.19	0.60	0.23	0.54	0.18	0.57	0.20
Arsenic	U	0.50	4.7	0.94	15	1.2	10	0.91	12	1.0
Barium	U	0.10	2.2 J+ 0.19		5.2 J+ 0.23		4.1 J+ 0.18		4.3 J+ 0.20	
Beryllium	U	0.10	U	0.19	U	0.23	U	0.18	U	0.20
Cadmium	U	0.10	U	0.19	U	0.23	U	0.18	U	0.20
Chromium	U	0.30	5.0	0.56	2.6	0.69	2.8	0.55	4.6	0.60
Cobalt	U	0.10	0.73	0.19	0.97	0.23	1.1	0.18	1.2	0.20
Copper	0.76 J+ 0.10		12 J+ 0.19		9.7 J+ 0.23		11 J+ 0.18		12 J+ 0.20	
Lead	U	0.10	24	0.19	56	0.23	66	0.18	69	0.20
Manganese	0.11 J+ 0.10		120 J- 0.19		230 J- 0.23		250 J- 0.18		280 J- 0.20	
Nickel	U	0.10	2.6 J+ 0.19		4.0 J+ 0.23		4.7 J+ 0.18		3.4 J+ 0.20	
Selenium	U	0.50	U	0.94	U	1.2	U	0.91	U	1.0
Silver	U	0.10	U	0.19	U	0.23	U	0.18	U	0.20
Thallium	U	0.20	U	0.38	U	0.46	U	0.36	U	0.40
Tin	U	10	U	19	U	23	U	18	U	20
Vanadium	U	0.50	12	0.94	20	1.2	13	0.91	23	1.0
Zinc	U	1.0	32	1.9	51	2.3	41	1.8	51	2.0

Table 1.1 (cont) Results of the Analysis for Metals in Tissue
WA # 356 Laurence Harbor Site
Results are Based on Dry Weight

Method : SW846 6020

Sample Number	356-0046		9/29/2008		CO2 BLANK	
Sample Location	Ulva-5		Method Blank		CO2 BLANK	
Percent Solids	17		--		--	
Analyte	Result mg/Kg	RL mg/Kg	Result ug/L	RL ug/L	Result ug/L	RL ug/L
Aluminum	770	J+ 62	U	300	U	300
Antimony	0.75	0.21	U	1.0	U	1.0
Arsenic	6.3	1.0	U	5.0	U	5.0
Barium	3.0	J+ 0.21	U	1.0	1.7	1.0
Beryllium	U	0.21	U	1.0	U	1.0
Cadmium	U	0.21	U	1.0	U	1.0
Chromium	3.4	0.62	U	3.0	U	3.0
Cobalt	1.2	0.21	U	1.0	U	1.0
Copper	13	J+ 0.21	U	1.0	2.0	J+ 1.0
Lead	80	0.21	U	1.0	U	1.0
Manganese	280	J- 0.21	U	1.0	1.3	J+ 1.0
Nickel	3.6	J+ 0.21	U	1.0	1.2	1.0
Selenium	U	1.0	U	5.0	U	5.0
Silver	U	0.21	U	1.0	U	1.0
Thallium	U	0.41	U	2.0	U	2.0
Tin	U	21	U	100	U	100
Vanadium	7.4	1.0	U	5.0	U	5.0
Zinc	38	2.1	U	10	U	10

Table 1.2 Result of the Analysis for Metals in Sediment
WA # 356 Laurence Harbor Site
Results are Based on Dry Weight

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Method : SW846 6020

Sample Number	9/30/2008		356-0011		356-0012		356-0013		356-0014	
Sample Location	Method Blank		SS-RM1		SS-RM2		SS-RM3		SS-RM4	
Percent Solids	--		78		78		80		72	
	Result	RL	Result	RL	Result	RL	Result	RL	Result	RL
Analyte	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg
Aluminum	U	30	1400	33	1000	28	1500	27	1300	23
Antimony	U	0.10	0.22	0.11	0.31	0.095	0.49	0.089	1.5	0.077
Arsenic	U	0.50	5.6 J	0.56	6.1 J	0.47	8.5 J	0.44	6.9 J	0.38
Barium	U	0.10	2.8 J+	0.11	1.7 J+	0.095	2.4 J+	0.089	6.8	0.077
Beryllium	U	0.10	0.14	0.11	0.18	0.095	0.31	0.089	0.16	0.077
Cadmium	U	0.10	0.14	0.11	U	0.095	0.22	0.089	0.13	0.077
Chromium	U	0.30	9.0	0.33	9.5	0.28	21	0.27	7.7	0.23
Cobalt	U	0.10	0.60	0.11	1.5	0.095	0.92	0.089	0.93	0.077
Copper	U	1.0	4.4 J+	1.1	9.9 J+	0.95	15	0.89	11	0.77
Lead	U	0.10	12	0.11	16	0.095	19	0.089	94	0.077
Manganese	0.11	0.10	22 J	0.11	44 J	0.095	48 J	0.089	28 J	0.077
Nickel	U	0.10	1.6 J+	0.11	3.0	0.095	2.6	0.089	2.3 J+	0.077
Selenium	U	0.50	U	0.56	U	0.47	U	0.44	U	0.38
Silver	U	0.10	U	0.11	U	0.095	U	0.089	0.080	0.077
Thallium	U	0.20	U	0.22	U	0.19	U	0.18	U	0.15
Tin	U	10	U J	11	U J	9.5	U J	8.9	8.0 J	7.7
Vanadium	U	0.50	26	0.56	21	0.47	38	0.44	17	0.38
Zinc	U	1.0	25	1.1	31	0.95	33	0.89	40	0.77

Table 1.2 (cont) Result of the Analysis for Metals in Sediment
WA # 356 Laurence Harbor Site
Results are Based on Dry Weight

Method : SW846 6020

Sample Number	356-0015		356-0016		356-0017		356-0018		356-0019	
Sample Location	SS-RM5		SS-RM6		SS-MM1		SS-MM2		SS-MM3	
Percent Solids	72		79		71		77		67	
	Result	RL	Result	RL	Result	RL	Result	RL	Result	RL
Analyte	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg
Aluminum	2900	62	4200	30	1600	26	3000	30	2700	41
Antimony	6.1	0.10	1.6	0.099	1.1	0.087	0.84	0.10	1.2	0.14
Arsenic	13 J	0.51	29 J	0.50	9.4 J	0.43	15 J	0.50	5.4 J	0.68
Barium	8.9	0.10	5.5	0.099	4.3 J+	0.087	4.0 J+	0.10	5.5	0.14
Beryllium	0.29	0.10	0.66	0.099	0.25	0.087	0.74	0.10	0.22	0.14
Cadmium	U	0.10	0.33	0.099	0.34	0.087	0.15	0.10	0.42	0.14
Chromium	18	0.31	46	0.30	15	0.26	37	0.30	14	0.41
Cobalt	2.3	0.10	3.8	0.099	1.5	0.087	1.9	0.10	0.78	0.14
Copper	22	1.0	17	0.99	13	0.87	11	1.0	31	1.4
Lead	660	0.20	93	0.099	47	0.087	29	0.10	83	0.14
Manganese	260 J	0.10	99 J	0.099	29 J	0.087	56 J	0.10	19 J	0.14
Nickel	5.8	0.10	8.5	0.099	5.0	0.087	6.6	0.10	2.9	0.14
Selenium	U	0.51	U	0.50	U	0.43	U	0.50	U	0.68
Silver	0.19	0.10	0.12	0.099	0.13	0.087	U	0.10	1.1	0.14
Thallium	U	0.20	U	0.20	U	0.17	U	0.20	U	0.27
Tin	18 J	10	U J	9.9	8.7 J	8.7	U J	10	U J	14
Vanadium	29	0.51	76	0.50	29	0.43	84	0.50	36	0.68
Zinc	57	1.0	91	0.99	68	0.87	91	1.0	53	1.4

Table 1.2 (cont) Result of the Analysis for Metals in Sediment
WA # 356 Laurence Harbor Site
Results are Based on Dry Weight

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Method : SW846 6020

Sample Number	356-0020	356-0021	356-0022
Sample Location	SS-MM4	SS-MM5	Sediment Blank
Percent Solids	69	71	100

Analyte	Result mg/Kg	RL mg/Kg	Result mg/Kg	RL mg/Kg	Result mg/Kg	RL mg/Kg
Aluminum	3000	30	2000	26	86	28
Antimony	0.42	0.099	0.47	0.087	U	0.093
Arsenic	12 J	0.50	7.4 J	0.44	U J	0.46
Barium	5.0	0.099	3.4 J+	0.087	0.44	0.093
Beryllium	0.46	0.099	0.33	0.087	U	0.093
Cadmium	0.17	0.099	0.13	0.087	U	0.093
Chromium	44	0.30	11	0.26	0.61	0.28
Cobalt	1.7	0.099	1.2	0.087	U	0.093
Copper	9.4 J+	0.99	7.4 J+	0.87	1.0	0.93
Lead	26	0.099	24	0.087	0.26	0.093
Manganese	55 J	0.099	32 J	0.087	3.8 J	0.093
Nickel	4.9	0.099	2.8	0.087	0.26	0.093
Selenium	U	0.50	U	0.44	U	0.46
Silver	U	0.099	U	0.087	U	0.093
Thallium	U	0.20	U	0.17	U	0.18
Tin	U J	9.9	U J	8.7	U J	9.3
Vanadium	73	0.50	28	0.44	U	0.46
Zinc	56	0.99	44	0.87	U	0.93

Table 1.3 Result of the Analysis for Metals in Water
WA # 356 Laurence Harbor Site

Method : SW846 6020

Page 1 of 2

Sample Number	9/29/2008		356-0047		356-0053		356-0054		356-0055	
Sample Location	Method Blank		PW-A1 (Total/Unfiltered)		PW-A2 (Filtered)		PW-B1 (Total/Unfiltered)		PW-B2 (Filtered)	
Analyte	Result ug/L	RL ug/L	Result ug/L	RL ug/L	Result ug/L	RL ug/L	Result ug/L	RL ug/L	Result ug/L	RL ug/L
Aluminum	U	300	U	1200	U	600	U	600	U	600
Antimony	U	1.0	U	4.0	U	2.0	U	2.0	U	2.0
Arsenic	U	5.0	U	20	11	10	19	10	23	10
Barium	U	1.0	46	4.0	43	2.0	25	2.0	24	2.0
Beryllium	U	1.0	U	8.0	U	4.0	U	4.0	U	2.0
Cadmium	U	1.0	U	4.0	U	2.0	U	2.0	U	2.0
Chromium	U	3.0	U	12	U	6.0	7.6	6.0	6.6	6.0
Cobalt	U	1.0	U	4.0	U	2.0	U	2.0	U	2.0
Copper	U	10	U	80	U	40	U	40	U	20
Lead	U	1.0	U	8.0	U	4.0	10	4.0	U	2.0
Manganese	U	1.0	810	4.0	840	2.0	540	2.0	530	2.0
Nickel	U	1.0	9.6	4.0	7.3	2.0	6.9	2.0	4.9	2.0
Selenium	U	5.0	U	40	U	25	U	20	U	10
Silver	U	1.0	U	4.0	U	2.0	U	2.0	U	2.0
Thallium	U	2.0	U	8.0	U	4.0	U	4.0	U	4.0
Tin	U	100	U	400	U	200	U	200	U	200
Vanadium	U	5.0	U	20	U	10	U	10	U	10
Zinc	U	10	U	40	U	20	U	20	U	20

Table 1.3 (cont) Result of the Analysis for Metals in Water
WA # 356 Laurence Harbor Site

Method : SW846 6020

Sample Number	356-0056		356-0057		356-0058		356-0059		356-0060	
Sample Location	PW-C1 (Total/Unfiltered)		PW-C2 (Filtered)		PW-D1 (Total/Unfiltered)		PW-D2 (Filtered)		PW-E1 (Total/Unfiltered)	
Analyte	Result ug/L	RL ug/L	Result ug/L	RL ug/L	Result ug/L	RL ug/L	Result ug/L	RL ug/L	Result ug/L	RL ug/L
Aluminum	U	600	U	600	1900	600	U	600	U	600
Antimony	56	2.0	19	2.0	270	2.0	130	2.0	9.7	2.0
Arsenic	71	10	41	10	230	10	86	10	39	10
Barium	39	2.0	35	2.0	47	2.0	34	2.0	26	2.0
Beryllium	U	2.0	U	2.0	U	2.0	U	2.0	U	2.0
Cadmium	U	2.0	U	2.0	U	2.0	U	2.0	U	2.0
Chromium	9.8	6.0	6.6	6.0	17	6.0	7.1	6.0	7.9	6.0
Cobalt	3.2	2.0	2.0	2.0	7.4	2.0	U	2.0	3.3	2.0
Copper	U	40	U	20	91	40	U	40	U	40
Lead	1500	4.0	U	2.0	2400	4.0	170	4.0	160	4.0
Manganese	1800	2.0	1800	2.0	1300	2.0	1100	2.0	2300	2.0
Nickel	10	2.0	6.1	2.0	33	2.0	11	2.0	5.8	2.0
Selenium	U	25	U	10	U	50	U	10	U	20
Silver	U	2.0	U	2.0	U	2.0	U	2.0	U	2.0
Thallium	U	4.0	U	4.0	U	4.0	U	4.0	U	4.0
Tin	U	200	U	200	U	200	U	200	U	200
Vanadium	11	10	U	10	21	10	12	10	U	10
Zinc	27	20	U	20	150	20	U	20	U	20

Table 1.3 (cont) Result of the Analysis for Metals in Water
WA # 356 Laurence Harbor Site

Method : SW846 6020

Page 2 of 2

Sample Number 356-0061
Sample Location PW-E2 (Filtered)

Analyte	Result ug/L	RL ug/L
Aluminum	U	600
Antimony	4.0	2.0
Arsenic	29	10
Barium	25	2.0
Beryllium	U	2.0
Cadmium	U	2.0
Chromium	6.4	6.0
Cobalt	3.1	2.0
Copper	U	20
Lead	U	2.0
Manganese	2200	2.0
Nickel	5.5	2.0
Selenium	U	10
Silver	U	2.0
Thallium	U	4.0
Tin	U	200
Vanadium	U	10
Zinc	U	20

Table 2.1 Results of the MS/MSD Analysis for Metals in Tissue
WA # 356 Laurence Harbor Site
Results are Based on Dry Weight

Page 1 of 1

Sample Number: 356-0023

Analyte	Sample Conc mg/kg	MS Spike Added mg/kg	MS Conc mg/kg	MS % Recovery	MSD Spike Added mg/kg	MSD Conc mg/kg	MSD % Recovery	RPD	QC Limits	
									% Recovery	RPD
Aluminum	44	460	480	95	440	480	99	2	75.0-125	20
Antimony	0.14	120	100	88	110	96	88	5	75.0-125	20
Arsenic	7.7	120	110	90	110	100	88	7	75.0-125	20
Barium	0.60	460	420	91	440	380	87	10	75.0-125	20
Beryllium	U	12	10	89	11	10	91	3	75.0-125	20
Cadmium	0.83	58	53	90	55	49	88	8	75.0-125	20
Chromium	2.3	46	44	89	44	40	87	8	75.0-125	20
Cobalt	0.28	120	100	90	110	98	89	7	75.0-125	20
Copper	14	58	67	91	55	62	87	8	75.0-125	20
Lead	3.0	120	110	90	110	100	89	6	75.0-125	20
Manganese	5.3	120	110	89	110	100	87	8	75.0-125	20
Nickel	0.54	120	104	89	110	98	89	6	75.0-125	20
Selenium	2.6	120	110	89	110	97	87	8	75.0-125	20
Silver	0.76	12	11	89	11	10	85	9	75.0-125	20
Thallium	U	120	100	88	110	94	86	7	75.0-125	20
Tin	7.3	120	110	87	110	100	87	5	75.0-125	20
Vanadium	0.79	120	110	91	110	99	89	8	75.0-125	20
Zinc	57	120	160	87	110	150	84	6	75.0-125	20

Sample Number: 356-0043

	Sample	MS Spike	MS			MSD	MSD				QC Limits	
Analyte	Conc	Added	Conc	MS		Spike Added	Conc	MSD		RPD	% Recovery	RPD
	mg/kg	mg/kg	mg/kg	% Recovery		mg/kg	mg/kg	% Recovery				
Aluminum	480	470	1200	165	*	470	1300	177	*	5	75.0-125	20
Antimony	0.60	120	110	94		120	110	93		1	75.0-125	20
Arsenic	15	120	120	93		120	120	92		0	75.0-125	20
Barium	5.2	470	450	94		470	450	95		1	75.0-125	20
Beryllium	U	12	12	103		12	12	101		0	75.0-125	20
Cadmium	U	58	56	96		59	57	96		1	75.0-125	20
Chromium	2.6	47	46	92		47	45	90		1	75.0-125	20
Cobalt	0.97	120	110	93		120	110	92		0	75.0-125	20
Copper	9.7	58	69	101		59	72	105		5	75.0-125	20
Lead	56	120	160	88		120	160	89		2	75.0-125	20
Manganese	230	120	310	72	*	120	380	124		18	75.0-125	20
Nickel	4.0	120	110	94		120	110	92		0	75.0-125	20
Selenium	U	120	110	93		120	110	93		2	75.0-125	20
Silver	U	12	11	96		12	11	94		1	75.0-125	20
Thallium	U	120	110	92		120	110	92		1	75.0-125	20
Tin	U	120	120	107		120	120	105		0	75.0-125	20
Vanadium	20	120	130	91		120	130	90		0	75.0-125	20
Zinc	51	120	160	90		120	160	89		0	75.0-125	20

Table 2.2 Results of the MS/MSD Analysis for Metals in Sediment
WA # 356 Laurence Harbor Site
Results are Based on Dry Weight

Sample Number: 356-0011

Analyte	Sample Conc mg/kg	MS Spike Added mg/kg	MS Conc mg/kg	MS % Recovery	MSD Spike Added mg/kg	MSD Conc mg/kg	MSD % Recovery	RPD	QC Limits	
									% Recovery	RPD
Aluminum	1400	220	2400	NC	220	2500	NC	4	75-125	20
Antimony	0.23	54	45	82	55	46	83	2	75-125	20
Arsenic	5.6	54	59	98	55	56	93	4	75-125	20
Barium	2.8	220	210	94	220	210	93	0	75-125	20
Beryllium	0.14	5.4	5.1	91	5.5	5.2	92	2	75-125	20
Cadmium	0.14	27	26	93	27	25	91	2	75-125	20
Chromium	9.0	22	34	115	22	33	109	4	75-125	20
Cobalt	0.60	54	53	97	55	54	97	1	75-125	20
Copper	4.4	27	30	94	27	30	94	1	75-125	20
Lead	12	54	72	110	55	61	90	16	75-125	20
Manganese	22	54	82	110	55	100	145	* 22 *	75-125	20
Nickel	1.6	54	54	97	55	55	98	2	75-125	20
Selenium	U	54	51	94	55	50	91	2	75-125	20
Silver	U	5.4	5.1	93	5.5	5.1	92	1	75-125	20
Thallium	U	54	52	96	55	51	93	2	75-125	20
Tin	U	54	73	128	* 55	58	99	24 *	75-125	20
Vanadium	26	54	84	107	55	72	85	15	75-125	20
Zinc	25	54	75	93	55	78	97	3	75-125	20

Table 2.3 Results of the MS Analysis for Metals in Water
WA # 356 Laurence Harbor Site

Sample Number: 356-0047

Analyte	Sample Conc µg/L	MS Spike Added µg/L	MS Conc µg/L	MS % Recovery	QC Limits % Recovery
Aluminum	U	2000	2400	106	75-125
Antimony	U	500	500	99	75-125
Arsenic	U	500	500	98	75-125
Barium	46	2000	1900	94	75-125
Beryllium	U	50	43	86	75-125
Cadmium	U	250	210	84	75-125
Chromium	U	200	190	92	75-125
Cobalt	U	500	450	89	75-125
Copper	U	250	230	90	75-125
Lead	U	500	490	97	75-125
Manganese	810	500	1200	80	75-125
Nickel	9.6	500	440	85	75-125
Selenium	U	500	430	86	75-125
Silver	U	50	42	83	75-125
Thallium	U	500	490	98	75-125
Tin	U	500	520	103	75-125
Vanadium	U	500	500	98	75-125
Zinc	U	500	430	81	75-125

Table 2.4 Results of the LCS Analysis for Metals in Tissue
 WA # 356 Laurence Harbor Site
 Results are Based on Dry Weight

Page 1 of 1

Date Analyzed 10/1/08

Analyte	LCS Spike Added mg/kg	LCS Conc mg/kg	% Recovery	QC Limits % Recovery
Aluminum	20	22	109	80-120
Antimony	5.0	4.7	95	80-120
Arsenic	5.0	4.8	95	80-120
Barium	20	19	95	80-120
Beryllium	0.5	0.45	90	80-120
Cadmium	2.5	2.4	95	80-120
Chromium	2.0	1.9	95	80-120
Cobalt	5.0	4.7	94	80-120
Copper	2.5	2.4	97	80-120
Lead	5.0	4.7	94	80-120
Manganese	5.0	4.6	92	80-120
Nickel	5.0	4.8	95	80-120
Selenium	5.0	4.7	94	80-120
Silver	0.5	0.48	96	80-120
Thallium	5.0	4.6	91	80-120
Tin	5.0	5.1	103	80-120
Vanadium	5.0	4.7	94	80-120
Zinc	5.0	4.8	96	80-120

Date Analyzed 10/2/08

Analyte	LCS Spike Added mg/kg	LCS Conc mg/kg	% Recovery	QC Limits % Recovery
Aluminum	20	21	105	80-120
Antimony	5.0	4.8	97	80-120
Arsenic	5.0	4.7	94	80-120
Barium	20	19	95	80-120
Beryllium	0.5	0.51	101	80-120
Cadmium	2.5	2.4	95	80-120
Chromium	2.0	1.8	92	80-120
Cobalt	5.0	4.6	93	80-120
Copper	2.5	2.4	96	80-120
Lead	5.0	4.7	94	80-120
Manganese	5.0	4.6	91	80-120
Nickel	5.0	4.6	93	80-120
Selenium	5.0	4.6	93	80-120
Silver	0.5	0.47	94	80-120
Thallium	5.0	4.6	92	80-120
Tin	5.0	5.3	107	80-120
Vanadium	5.0	4.6	91	80-120
Zinc	5.0	4.7	93	80-120

Table 2.5 Results of the LCS/LCSD Analysis for Metals in Water
WA # 356 Laurence Harbor Site

Page 1 of 1

Date Analyzed 09/29/08

Analyte	LCS/LCSD Spike Added µg/L	LCS Conc. µg/L	LCS % Recovery	LCSD Conc. µg/L	LCSD % Recovery	%RPD	QC Limits	
							% Recovery	%RPD
Aluminum	2000	2200	108	2100	103	4	80-120	20
Antimony	500	530	106	500	100	6	80-120	20
Arsenic	500	520	104	490	98	6	80-120	20
Barium	2000	2000	101	1900	96	5	80-120	20
Beryllium	50	52	105	55	111	6	80-120	20
Cadmium	250	260	106	250	101	4	80-120	20
Chromium	200	190	96	190	93	3	80-120	20
Cobalt	500	490	97	470	94	3	80-120	20
Copper	250	250	100	240	96	4	80-120	20
Lead	500	510	101	480	97	4	80-120	20
Manganese	500	480	96	460	92	5	80-120	20
Nickel	500	490	98	470	94	4	80-120	20
Selenium	500	510	101	480	96	5	80-120	20
Silver	50	51	102	49	98	4	80-120	20
Thallium	500	480	97	470	95	3	80-120	20
Tin	500	560	112	530	106	6	80-120	20
Vanadium	500	470	95	460	92	3	80-120	20
Zinc	500	490	99	480	95	4	80-120	20

Table 2.6 Results of the LCS Analysis for Metals in Sediment
 WA # 356 Laurence Harbor Site
 Results are Based on Dry Weight

Page 1 of 1

Date Analyzed 09/30/08

Analyte	LCS Spike Added mg/kg	LCS Conc mg/kg	% Recovery	QC Limits
				% Recovery
Aluminum	7900	9700	123	59-141
Antimony	71	52	74	0-211
Arsenic	290	270	93	81-119
Barium	210	200	95	82-117
Beryllium	54	51	93	83-117
Cadmium	100	93	93	82-118
Chromium	220	240	109	80-120
Cobalt	100	100	100	82-118
Copper	88	84	95	83-117
Lead	160	140	88	82-118
Manganese	420	420	100	82-118
Nickel	120	120	100	83-118
Selenium	130	120	92	78-122
Silver	100	100	100	66-134
Thallium	94	90	96	77-122
Tin	150	160	107	70-130
Vanadium	110	120	109	77-123
Zinc	270	260	96	79-121

Table 2.7 Results of the Duplicate Analysis for Metals in Water
WA # 356 Laurence Harbor Site

Page 1 of 1

Sample Number: 356-0054

Analyte	Initial Analysis µg/L	Duplicate Analysis µg/L	RPD	QC Limits % RPD
Aluminum	U	U	NC	20
Antimony	U	U	NC	20
Arsenic	19	22	14	20
Barium	25	26	6	20
Beryllium	U	U	NC	20
Cadmium	U	U	NC	20
Chromium	7.6	8.2	8	20
Cobalt	U	U	NC	20
Copper	U	U	NC	20
Lead	10	10	1	20
Manganese	540	550	1	20
Nickel	6.9	6.7	3	20
Selenium	U	U	NC	20
Silver	U	U	NC	20
Thallium	U	U	NC	20
Tin	U	U	NC	20
Vanadium	U	U	NC	20
Zinc	U	U	NC	20

From: Lyons, Larry A
Sent: Friday, September 26, 2008 12:40 PM
To: 'Andrea Colby'
Cc: Johnson, John M; Wentz, Erica L
Subject: RE: Project 0356 TCLP Metals
Andrea,

The 10 samples that were marked for TCLP analyses have been cancelled. Would you please ship those samples back to us next week. The samples are identified as follows:

356-0006
356-0007
356-0008
356-0009
356-0010
356-0048
356-0049
356-0050
356-0051
356-0052

Thank you,

Larry A. Lyons
Lockheed Martin/REAC
4890 Woodbridge Ave.
Bldg 209 Annex
Edison, NJ 08037

Phone: 732-494-4075

From: Johnson, John M
Sent: Friday, September 26, 2008 8:21 AM
To: Andrea Colby
Cc: Lyons, Larry A
Subject: RE: Project 0356 TCLP Metals

Yes, your only doing the 18 metals that was on the original bid list.

From: Andrea Colby [mailto:acolby@katahdinlab.com]
Sent: Thursday, September 25, 2008 4:39 PM
To: Johnson, John M
Subject: RE: Project 0356 TCLP Metals

Hi John,
The COC is marked for TAL metals plus tin. Please confirm we are only doing the 18 metals in the bid request.
Thanks,
Andrea

From: Johnson, John M [mailto:john.m.johnson@lmco.com]
Sent: Thursday, September 25, 2008 8:13 AM
To: acolby@katahdinlab.com
Cc: Lyons, Larry A; Wentz, Erica L
Subject: Project 0356 TCLP Metals

Andrea please do not analyze the samples marked for TCLP analysis that you should receive today on COC 356-09/24/08-0009. Please just hold for further instructions.

0356-DAR-110308

018

file://I:\DataVal\REAC 4.0 (SUB DATA)\0356\Communication\RE Project 0356 TCLP ... 10/30/2008

Laurence Harbor Site

Site #: 356

Contact Phone: (732)494-4075

Lab: Katahdin Analytical

<p>Special Instructions: Lab chooses sample for MS/MSD analysis; <i>All samples to be homogenized</i></p>	<p>SAMPLES TRANSFERRED FROM</p> <p>CHAIN OF CUSTODY #</p>
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20

CHAIN OF CUSTODY RECORD

No: 356-09/15/08-0004

Site #: 356

Contact Name: Larry Lyons

Contact Phone: (732) 494-4075

Lab: Katahdin Analytical

0356-DAR-110308

REAC, Edison, NJ

Laurence Harbor Site

Lab #	Sample #	Location	Analyses	Matrix	Collected	Numb Cont	Container	Preservative	MS/MSD
	356-0029	Mya-1	TAL Metals plus Sn, % Solids	Tissue	9/10/2008	1	4 oz. glass jar	-20 C/Dry Ice	*
	356-0030	Mya-2	TAL Metals plus Sn, % Solids	Tissue	9/10/2008	1	4 oz. glass jar	-20 C/Dry Ice	↓
	356-0031	Mya-3	TAL Metals plus Sn, % Solids	Tissue	9/10/2008	1	4 oz. glass jar	-20 C/Dry Ice	
	356-0032	Mya-4	TAL Metals plus Sn, % Solids	Tissue	9/10/2008	1	4 oz. glass jar	-20 C/Dry Ice	
	356-0033	Mya-5	TAL Metals plus Sn, % Solids	Tissue	9/10/2008	1	4 oz. glass jar	-20 C/Dry Ice	
<div>EW</div>									

020

*
Special Instructions: Lab chooses sample for MS/MSD analysis; All samples to be homogenized

SAMPLES TRANSFERRED FROM
CHAIN OF CUSTODY #

Items/Reason	Relinquished by	Date	Received by	Date	Time	Items/Reason	Relinquished By	Date	Received by	Date	Time
Analyses	L. Lyons	9/18/08									

0000009

CHAIN OF CUSTODY RECORD

No: 356-09/15/08-0005

Site #: 356

Contact Name: Larry Lyons

Contact Phone: (732) 494-4075

Lab: Katahdin Analytical

0356-DAR-110308

REAC, Edison, NJ

Laurence Harbor Site

Lab #	Sample #	Location	Analyses	Matrix	Collected	Numb Cont	Container	Preservative	MS/MSD
	356-0034	Mer-1	TAL Metals plus Sn, % Solids	Tissue	9/11/2008	1	4 oz. glass jar	-20 C/Dry Ice	*
	356-0035	Mer-2	TAL Metals plus Sn, % Solids	Tissue	9/11/2008	1	4 oz. glass jar	-20 C/Dry Ice	
	356-0036	Mer-3	TAL Metals plus Sn, % Solids	Tissue	9/11/2008	1	8 oz. glass jar	-20 C/Dry Ice	↓
<div style="position: absolute; top: 50%; left: 50%; transform: translate(-50%, -50%); font-size: 2em;">EW</div>									

021

*
Special Instructions: Lab chooses sample for MS/MSD analysis; All samples to be homogenized

SAMPLES TRANSFERRED FROM
CHAIN OF CUSTODY #

Items/Reason	Relinquished by	Date	Received by	Date	Time	Items/Reason	Relinquished By	Date	Received by	Date	Time
Analyses	L.A. Lyons	9/18/08									

0000010

CHAIN OF CUSTODY RECORD

No: 356-09/15/08-0006

REAC, Edison, NJ

Site #: 356

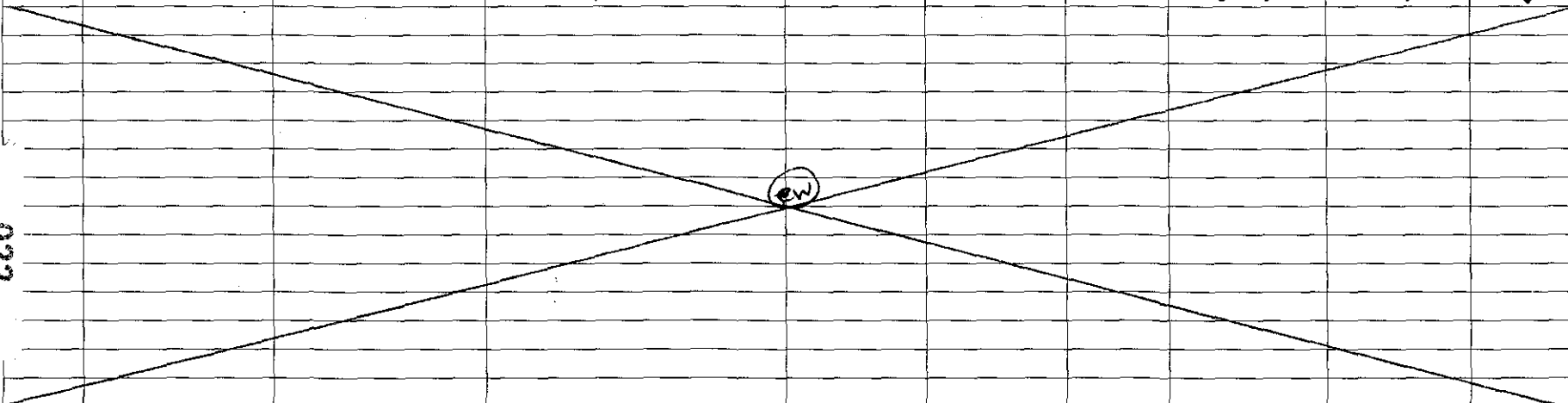
Contact Name: Larry Lyons

Lab: Katahdin Analytical

Laurence Harbor Site

Contact Phone: (732) 494-4075

0356-DAR-110308

Lab #	Sample #	Location	Analyses	Matrix	Collected	Numb Cont	Container	Preservative	MS/MSD
	356-0037	FF-1	TAL Metals plus Sn, % Solids	Tissue	9/10/2008	1	8 oz glass jar	-20 C/Dry Ice	*
	356-0038	FF-2	TAL Metals plus Sn, % Solids	Tissue	9/10/2008	1	8 oz glass jar	-20 C/Dry Ice	
	356-0039	FF-3	TAL Metals plus Sn, % Solids	Tissue	9/10/2008	1	8 oz glass jar	-20 C/Dry Ice	
	356-0040	FF-4	TAL Metals plus Sn, % Solids	Tissue	9/10/2008	1	8 oz glass jar	-20 C/Dry Ice	
	356-0041	FF-5	TAL Metals plus Sn, % Solids	Tissue	9/10/2008	1	8 oz glass jar	-20 C/Dry Ice	
									

022

Special Instructions: * Lab chooses sample for MS/MSD analysis;

All samples to be homogenized

SAMPLES TRANSFERRED FROM

CHAIN OF CUSTODY #

Items/Reason	Relinquished by	Date	Received by	Date	Time	Items/Reason	Relinquished By	Date	Received by	Date	Time
Analyses	L. A. Lyons	9/18/08									

0000011

CHAIN OF CUSTODY RECORD

No: 356-09/15/08-0007

0356-DAR-110308

REAC, Edison, NJ

Site #: 356

Contact Name: Larry Lyons

Lab: Katahdin Analytical

Laurence Harbor Site

Contact Phone: (732) 494-4075

Lab #	Sample #	Location	Analyses	Matrix	Collected	Numb Cont	Container	Preservative	MS/MSD
	356-0042	Ulva-1	TAL Metals plus Sn, % Solids	Plant Tissue	9/10/2008	1	4 oz. glass jar	-20 C/Dry Ice	*
	356-0043	Ulva-2	TAL Metals plus Sn, % Solids	Plant Tissue	9/10/2008	1	4 oz. glass jar	-20 C/Dry Ice	
	356-0044	Ulva-3	TAL Metals plus Sn, % Solids	Plant Tissue	9/10/2008	1	4 oz. glass jar	-20 C/Dry Ice	
	356-0045	Ulva-4	TAL Metals plus Sn, % Solids	Plant Tissue	9/10/2008	1	4 oz. glass jar	-20 C/Dry Ice	
	356-0046	Ulva-5	TAL Metals plus Sn, % Solids	Plant Tissue	9/10/2008	1	4 oz. glass jar	-20 C/Dry Ice	

023

*
Special Instructions: Lab chooses sample for MS/MSD analysis; All samples to be homogenized

SAMPLES TRANSFERRED FROM
CHAIN OF CUSTODY #

Items/Reason	Relinquished by	Date	Received by	Date	Time	Items/Reason	Relinquished By	Date	Received by	Date	Time
Analyses	L.A. Lyons	9/18/08									

000001a

SB5405

CHAIN OF CUSTODY RECORD

No: 356-09/24/08-0009

Site #: 356

Contact Name: Larry Lyons

Contact Phone: (732) 494-4075

Lab: Katahdin Analytical

0356-DAR-1-10308

REAC, Edison, NJ

Laurence Harbor Site

Lab #	Sample #	Location	Analyses	Matrix	Collected	Numb Cont	Container	Preservative	MS/MSD
	356-0006	RBS-S01A	TCLP	Sediment	9/11/2008	1	4 oz. glass jar	4 C	
	356-0007	RBS-S02A	TCLP	Sediment	9/11/2008	1	4 oz. glass jar	4 C	
	356-0008	RBS-S03A	TCLP	Sediment	9/11/2008	1	4 oz. glass jar	4 C	
	356-0009	RBS-S04A	TCLP	Sediment	9/11/2008	1	4 oz. glass jar	4 C	
	356-0010	RBS-S05A	TCLP	Sediment	9/11/2008	1	4 oz. glass jar	4 C	
	356-0011	SS-RM1	TAL Metals plus Sn, % Solids	Sediment	9/11/2008	1	4 oz. glass jar	4 C	
	356-0012	SS-RM2	TAL Metals plus Sn, % Solids	Sediment	9/11/2008	1	4 oz. glass jar	4 C	
	356-0013	SS-RM3	TAL Metals plus Sn, % Solids	Sediment	9/11/2008	1	4 oz. glass jar	4 C	
	356-0014	SS-RM4	TAL Metals plus Sn, % Solids	Sediment	9/11/2008	1	4 oz. glass jar	4 C	
	356-0015	SS-RM5	TAL Metals plus Sn, % Solids	Sediment	9/11/2008	1	4 oz. glass jar	4 C	
	356-0016	SS-RM6	TAL Metals plus Sn, % Solids	Sediment	9/11/2008	1	4 oz. glass jar	4 C	
	356-0017	SS-MM1	TAL Metals plus Sn, % Solids	Sediment	9/11/2008	1	4 oz. glass jar	4 C	
	356-0018	SS-MM2	TAL Metals plus Sn, % Solids	Sediment	9/11/2008	1	4 oz. glass jar	4 C	
	356-0019	SS-MM3	TAL Metals plus Sn, % Solids	Sediment	9/11/2008	1	4 oz. glass jar	4 C	
	356-0020	SS-MM4	TAL Metals plus Sn, % Solids	Sediment	9/11/2008	1	4 oz. glass jar	4 C	
	356-0021	SS-MM5	TAL Metals plus Sn, % Solids	Sediment	9/11/2008	1	4 oz. glass jar	4 C	
	356-0022	Sediment Blank	TAL Metals plus Sn, % Solids, TCLP	Sediment	9/11/2008	1	4 oz. glass jar	4 C	
	356-0047	PW-A1 (Total/Unfiltered)	TAL Metals plus Sn	Pore Water	9/22/2008	1	250 mL bottle	4 C	

Special Instructions: Lab chooses sample for MS/MSD analysis on both the sediment and the pore water samples.

Pore water samples are also preserved with pH < 2

SAMPLES TRANSFERRED FROM

CHAIN OF CUSTODY #

Items/Reason	Relinquished by	Date	Received by	Date	Time	Items/Reason	Relinquished By	Date	Received by	Date	Time
Analysis	L. A. Lyons	9/24/08	DM-DL	9-25-08	1000						

0000010

SB5405

CHAIN OF CUSTODY RECORD

No: 356-09/24/08-0009

Site #: 356

Contact Name: Larry Lyons

Contact Phone: (732) 494-4075

Lab: Katahdin Analytical

0356-DAR-110308

REAC, Edison, NJ

Laurence Harbor Site

Lab #	Sample #	Location	Analyses	Matrix	Collected	Numb Cont	Container	Preservative	MS/MSD
	356-0048	RBS-507A	TCLP	Sediment	9/11/2008	1	4 oz. glass jar	4 C	
	356-0049	RBS-S59A	TCLP	Sediment	9/11/2008	1	4 oz. glass jar	4 C	
	356-0050	RBS-S60A	TCLP	Sediment	9/11/2008	1	4 oz. glass jar	4 C	
	356-0051	RBS-S97	TCLP	Sediment	9/11/2008	1	4 oz. glass jar	4 C	
	356-0052	RBS-S98	TCLP	Sediment	9/11/2008	1	4 oz. glass jar	4 C	
	356-0053	PW-A2 (Filtered)	TAL Metals plus Sn	Pore Water	9/22/2008	1	175 mL bottle	4 C	
	356-0054	PW-B1 (Total/Unfiltered)	TAL Metals plus Sn	Pore Water	9/22/2008	1	250 mL bottle	4 C	
	356-0055	PW-B2 (Filtered)	TAL Metals plus Sn	Pore Water	9/22/2008	1	175 mL bottle	4 C	
	356-0056	PW-C1 (Total/Unfiltered)	TAL Metals plus Sn	Pore Water	9/22/2008	1	250 mL bottle	4 C	
	356-0057	PW-C2 (Filtered)	TAL Metals plus Sn	Pore Water	9/22/2008	1	175 mL bottle	4 C	
	356-0058	PW-D1 (Total/Unfiltered)	TAL Metals plus Sn	Pore Water	9/22/2008	1	250 mL bottle	4 C	
	356-0059	PW-D2 (Filtered)	TAL Metals plus Sn	Pore Water	9/22/2008	1	175 mL bottle	4 C	
	356-0060	PW-E1 (Total/Unfiltered)	TAL Metals plus Sn	Pore Water	9/22/2008	1	250 mL bottle	4 C	
	356-0061	PW-E2 (Filtered)	TAL Metals plus Sn	Pore Water	9/22/2008	1	175 mL bottle	4 C	

025

Special Instructions: Lab chooses sample for MS/MSD analysis on both the sediment and the pore water samples.

Pore water samples also preserved with pH < 2

SAMPLES TRANSFERRED FROM

CHAIN OF CUSTODY #

Items/Reason	Relinquished by	Date	Received by	Date	Time	Items/Reason	Relinquished By	Date	Received by	Date	Time
Analysis	L A Lyons	9/24/08	Dr. Dr. Dr.	9-25-08	1000						

0000011

APPENDIX C

PHOTOGRAPHS OF SLAG SAMPLES



Figure C-1: Sample SW-1



Figure C-2: Slag Boulder (SW-2)



Figure C-3: Sample SW-2



Figure C-4: Sample SW-3



Figure C-5: Sample SW-3



Figure C-6: Sample SW-4



Figure C-7: Sample SW-5 -Exterior



Figure C-8: Sample SW-5 - Interior



Figure C-9: Slag Boulder Jetty-1



Figure C-10: Slag Boulder Jetty-1



Figure C-11: Jetty-2A- exterior



Figure C-12: Jetty-2B- interior



Figure C-13: Jetty-3A- exterior



Figure C-14: Jetty-3B- interior



Figure C-15: Jetty-4 interior



Figure C-16: Jetty-5 Melted Conglomerate



Figure C-17: Jetty-5



Figure C-18: Jetty-6



Figure C-19: Jetty-7A - Exterior



Figure C-20: Jetty-7B- Interior



Figure C-21: West Jetty(WJ)-1



Figure C-22: West Jetty(WJ)-2